THE

POPULAR SCIENCE MONTHLY.

MARCH, 1892.

NEW CHAPTERS IN THE WARFARE OF SCIENCE.

XV. ASTRONOMY.

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PART I.

THE next great series of battles was fought regarding the relations of the earth to the heavenly bodies. In the early Church, astronomy, like other branches of science, was very generally looked upon as futile, in view of the doctrine, so prominent in the New Testament, that the earth was in its last days. At best, the heavenly bodies were only objects of pious speculation. Some theologians, remembering the beautiful poetic vision of the morning stars singing together, revived an old theory that the heavenly lights have immortal souls. Tertullian's view of the solar system is seen in his theory that an eclipse of the sun was simply a sign of the wrath of God against unbelief. St. Augustine gave forth as final truth in sacred science a statement, based upon the Psalms, that "the heavens are like a curtain"; but his view of any scientific study is shown by his ejaculation, "What concern is it to me whether the heavens as a sphere inclose the earth in the middle of the world, or overhang it on either side?"

The prevailing view in the Church was based upon the declarations in Genesis that a solid vault—a "firmament"—was extended above the earth, and that the heavenly bodies were simply lights hung within it. This view plays a great part in the sacred theory established so firmly by the monk Cosmas in the sixth century. Having based his plan of the universe upon various texts in the Old and New Testaments, and having made it a vast oblong box, covered by the solid "firmament," he brings in an additional

view from Scripture to account for the planetary movements, and develops at length the theory that the sun and planets are moved and the "windows of heaven" opened and shut by angels appointed for that purpose.

How intensely real this way of looking at the universe was, we find in the writings of St. Isidore, the greatest leader of orthodox thought in the seventh century. He affirms that since the fall of man, and on account of it, the sun and moon shine with a feebler light; but he proves from a text in Isaiah that when the world shall be fully redeemed these "great lights" will shine again in all their early splendor.* But despite these authorities and their theological finalities, the evolution of scientific thought continued, its main germ being the geocentric doctrine—the doctrine that the earth is the center, and that the sun and planets revolve about it.

This doctrine was of the highest respectability: it had been developed at a very early period, and had been elaborated until it accounted well for the apparent movements of the heavenly bodies; its final name—"Ptolemaic theory"—carried weight; and, having thus come from antiquity into the Christian world, it was finally acquiesced in and universally held to agree with the letter and spirit of Scripture.†

Wrought into this foundation, and based upon it, there was developed in the middle ages, by means of Scriptural texts and theological reasonings, a new sacred system of astronomy, which became one of the great treasures of the universal Church—the last word of revelation.

Three great men mainly reared this structure. First was the unknown who gave to the world the treatises ascribed to Dionysius the Areopagite. It was u[n]hesitatingly believed that these were the work of St. Paul's Athenian convert, and therefore virtually by St. Paul himself. Though now known to be spurious, they were then considered a treasure of inspiration, and an Em-

* For Tertullian's view of an eclipse of the sun, see the Ad Scapulam, cap. iii, in Migne, Patr. Lat., i, p. 701. For passage cited from Clement of Alexandria, see edition of T. Clark, Edinburgh, 1869, vol. ii, p. 368. For typical statements by St. Augustine, see De Genesi, ii, cap. ix, in Migne, Patr Lat., tome xxxiv, pp. 270, 271. For St. Isidore, see the De Ordine Creaturarum, cap. v, in Migne, Patr. Lat., lxxxiii, pp. 923–925; also, 1000, 1001. For Cosmas's view, see his Topographia Christiana in Montfauçon, Col. Nov. Patrum, ii, p. 150, and elsewhere as cited in my chapter on "Geography."

† As to the respectability of the geocentric theory, etc., see Grote's Plato, vol. iii, p. 257; also Sir G. C. Lewis's Astronomy of the Ancients, chap. iii, sec. 1, for a very thoughtful statement of Plato's view, and differing from ancient statements. For plausible elaboration of it, and for supposed agreement of Scripture with it, see Fromundus, Anti-Aristarchus, Antwerp, 1631; also Melanchthon's Initia Doctrinæ Physicæ. For an admirable statement of the theological view of the geocentric theory, antipodes, etc., see Eicken, *Geschichte der System der Mittelälterlichen Weltanschauung*, pp. 618 *et seq.*

peror of the East sent them to an Emperor of the West as the most worthy of gifts. In the ninth century they were widely made known in western Europe, and became a fruitful source of thought, especially on the whole celestial hierarchy; thus the old ideas of astronomy were vastly developed; and the heavenly hosts were classed and named in accordance with indications scattered through the sacred Scriptures.

The next of these three great theologians was Peter Lombard, professor at the University of Paris. About the middle of the twelfth century he gave forth his collection of "Sentences," or Statements by the Fathers, and this remained until the end of the middle ages the universal manual of theology. In it was especially developed the theological view of man's relation to the universe. The author tells the world: "Just as man is made for the sake of God—that is, that he may serve Him,—so the universe is made for the sake of man,—that is, that it may serve *him;* therefore is man placed at the middle point of the universe, that he may both serve and be served."

The vast significance of this view, and its power in resisting any real astronomical science, we shall see, especially in the time of Galileo.

The great triad of thinkers culminated in St. Thomas Aquinas, the sainted theologian, the glory of the mediæval Church, the "Angelic Doctor," the most marvelous intellect between Aristotle and Newton; he to whom it was believed that an image of the Crucified had spoken words praising his writings. Large of mind, strong, acute, yet just—even more than just—to his opponents, he gave forth, in the latter half of the thirteenth century, his Cyclopædia of Theology, the "Summa." In this he carried the sacred theory of the universe to its full development. With great power and clearness he brought the whole vast system, material and spiritual, into its relations to God and man.*

Such was the vast system developed by these three leaders of mediæval thought; and now came the man who wrought it yet more deeply into European belief, the poet divinely inspired who made the system part of the world's *life*. Under the touch of Dante the empyrean and the concentric heavens, paradise, purgatory, and hell, were seen of all men; the God Triune seated on his throne upon the circle of the heavens as real as the Pope seated

* For the contribution of the pseudo-Dionysius to mediæval cosmology see Dion., Areopagita, De Cælest. hierarch. vers. Joan. Scoti, in Migne, Patr. Lat., cxxii. For the contribution of Peter Lombard, see Pet. Lomb., Libr. Sent. II, i, 8; IV, i, 6, 7. For the citations from St. Thomas Aquinas, see the Summa, ed. Migne, especially Quæst. LXX, tome i, pp. 1174–1184; also Quæst. XLVII, Art. iii. For good general statement, see Milman, Latin Christianity, iv, 191 *et seq*; and for relation of Cosmas to these theologians of western Europe, see Milman, as above, viii, 228, note.

in the chair of St. Peter; the seraphim, cherubim, and thrones, surrounding the Almighty, as real as the cardinals surrounding the Pope; the three great orders of angels in heaven as real as the three great orders, bishops, priests, and deacons, on earth; and the whole system of spheres each revolving within the one above it and all moving about the earth, subject to the *primum mobile*, as real as the feudal system of western Europe, subject to the emperor.*

Let us look into this vast creation—the highest achievement of theology—somewhat more closely.

Its first feature shows an evolution: the earth is no longer the flat plain inclosed by four walls and solidly vaulted above, as theologians of previous centuries had believed it, under the inspiration of the monk Cosmas; it is no longer a mere flat disk with sun, moon, and stars hung up to give it light, as the earlier cathedral sculptors had figured it; it has become a globe at the center of the universe. Encompassing it are ten successive, transparent spheres, nine of them rotated by angels about the earth, and each carrying one of the heavenly bodies with it: that nearest the earth carrying the moon; the next, Mercury; the next, Venus; the next, the sun; the next three, Mars, Jupiter, and Saturn. The tenth heaven, inclosing all these, was the empyrean. This was immovable,—the boundary between creation and the great outer void; and here, in a light which no one can enter, the Triune God sat enthroned—the "music of the spheres" rising to him as they move.

In attendance upon the Divine Majesty, thus enthroned, are vast hosts of angels, and these are divided into three hierarchies, one serving in the empyrean, one in the heaven between the empyrean and the earth, and one on the earth.

Each of these hierarchies is divided into three choirs or orders; the first, into the orders of Seraphim, Cherubim, and Thrones; and the main occupation of these is to chant incessantly, to "continually cry" the divine praises.

The order of thrones conveys God's will to the second hierarchy—which serves in the movable heavens. This second hierarchy is also made up of three orders. The first of these, the

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* For the central sun, hierarchy of angels, and concentric circles, see Dante, Paradiso, canto xxviii. For the words of St. Thomas Aquinas, showing to Virgil and Dante the great theologians of the middle ages, see canto x, and in Dean Plumptre's translation, vol. ii, pp. 56 *et seq.*; also Botta, Dante, pp. 350, 351. As to Dante's deep religious feeling and belief in his own divine mission, see J. R. Lowell, Among my Books, vol. i, p. 36. For a remarkable series of colored engravings showing Dante's whole cosmology, see La Materia della Divina Commedia di Dante dichiarata in vi tavole, da Michelangelo Caetani, published by the monks of Monte Cassino, to whose kindness the writer is indebted for his copy.

order of Dominions, receives the divine commands; the second, the order of Powers, moves the heavens, sun, moon, planets, and stars, opens and shuts the "windows of heaven," and brings to pass all other celestial phenomona; the third, the order of Empire, guards the others.

The third and lowest hierarchy is also made up of three orders. First of these are the Principalities—the guardian spirits of nations and kingdoms: next come Archangels; these protect religion, and bear the prayers of the saints to the foot of God's throne: finally, come Angels; these care for earthly affairs in general—one being appointed to each mortal, and others taking charge of the qualities of plants, metals, stones, and the like. Throughout the whole system, from the great Triune God to the lowest group of angels, we see at work the mystic power attached to the triangle and sacred number three—the same which gave the triune idea to ancient Hindoo theology, which developed the triune deities in Egypt, and which transmitted this theological gift to the Christian world, especially through the Egyptian monk Athanasius.

Below the earth is hell. This is tenanted by the angels who rebelled under the lead of Lucifer, prince of the seraphim—the former favorite of the Trinity; but of these rebellious angels, some still rove among the planetary spheres, and give trouble to the good angels; others pervade the atmosphere about the earth—carrying lightning, storm, drought, and hail. Others infest earthly society, tempting men to sin; but Peter Lombard and St. Thomas Aquinas take pains to show that the work of these devils is, after all, but to discipline man or to mete out deserved punishment.

All this vast scheme had been so knit into the Ptolemaic view and interwoven with it by the use of biblical texts and theological reasonings that the resultant system of the universe was considered impregnable and final. To attack it was blasphemy.

This system stood for centuries. Great theological scientists in following ages, like Vincent de Beauvais and Cardinal d'Ailly, devoted themselves to showing not only that it was supported by Scripture, but that it supported Scripture. Thus was the geocentric theory imbedded in the beliefs and aspirations, in the hopes and fears, of Christendom down to the middle of the sixteenth century.*

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* For the earlier sacred cosmology of Cosmas, with citations from Montfaucon, see my chapter on Geography. For the views of the mediæval theologians, see foregoing notes in this chapter. For the passages of Scripture on which the theological part of this structure was developed, see especially Romans viii, 38; Ephesians i, 21; Colossians i, 16, and ii, 15; and innumerable passages in the Old Testament. As to the music of the spheres, see Dean Plumptre's Dante, vol. ii, p. 4, note. For an admirable summing up of the mediæval

But, on the other hand, there had been planted, long before, the germs of the heliocentric theory. In the sixth century before our era, Pythagoras, and after him Philolaus, had suggested the movement of the earth and planets about a central fire; and three centuries later, Aristarchus had restated the main truth with striking precision. Here comes in a proof that the antagonism between theological and scientific methods is not confined to Christianity; for this statement brought upon Aristarchus the charge of blasphemy, and drew after it a cloud of prejudice which hid the truth for six hundred years:—not until the fifth century of our era does it timidly appear in the thoughts of Martianus Capella: then it is again lost to sight for a thousand years, until in the fifteenth century, distorted and imperfect, it appears in the writings of Cardinal Nicholas de Cusa.

But in the shade cast by the vast system which had grown from the mind of the great theologians and from the heart of the great poet there had come to this truth neither bloom nor fruitage.

Quietly, however, the soil was receiving enrichment and the air warmth. The processes of mathematics were constantly improved, the heavenly bodies were steadily observed, and at length appeared, far off from the centers of thought, on the borders of Poland, a plain, simple-minded scholar, who first fairly uttered to the modern world the truth—now so commonplace, then so astounding,—that the sun and planets do not revolve about the earth, but that the earth and planets revolve about the sun; and this man was Nicholas Copernicus.

Copernicus had been a professor at Rome, and even as early as 1500 had announced his doctrine there, but more in the way of a scientific curiosity or paradox, as it had been previously held by Cardinal de Cusa, than as the statement of a system representing a great fact in nature. About thirty years later one of his disciples, Widmanstadt, had explained it to Clement VII; but it still remained a mere hypothesis, and soon, like so many others, disappeared from the public view. But to Copernicus, steadily studying the subject, it became more and more a reality, and as the truth grew within him he seemed to feel that

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cosmology in its relation to thought in general, see Rydberg, Magic of the Middle Ages, chapter i, whose admirable summary I have followed closely. For charts showing the continuance of this general view down to the beginning of the sixteenth century, see the various editions of the Margarita Philosophica, especially that of Strasburg, 1508, astronomical part. For interesting statements regarding the trinities of gods in ancient Egypt, see Sharpe, History of Egypt. The present writer once heard a lecture in Cairo, from an eminent Scotch Doctor of Medicine, to account for the ancient Hindoo and Egyptian sacred threes and trinities. The lecturer's theory was that when Jehovah came down into the garden of Eden and walked with Adam in "the cool of the day," he explained his triune character to Adam, and that from Adam it was spread abroad to the various ancient nations.

at Rome he was no longer safe. To announce his discovery there as a theory or a paradox might amuse the papal court, but to announce it as a truth—as *the* truth—was a far different matter. He therefore returned to his little town in Poland.

To publish his thought as it had now developed was evidently dangerous even there, and for more than thirty years it lay slumbering in the mind of Copernicus and of the friends to whom he had privately intrusted it.

At last he prepares his great work on the Revolutions of the Heavenly Bodies, and dedicates it to the Pope himself. He next seeks a place of publication: he dares not send it to Rome, for there are the rulers of the older Church ready to seize it; he dares not send it to Wittenberg, for there are the leaders of Protestantism no less hostile; it is therefore intrusted to Osiander, at Nuremberg.*

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* For germs of heliocentric theory planted long before, etc., see Sir G. C. Lewis; and for a succinct statement of the claims of Pythagoras, Philolaus, Aristarchus, and Martianus Capella, see Hoefer, Histoire de l'Astronomie, 1873, p. 107 *et seq.*; also, Heller, Geschichte der Physik, Stuttgart, 1882, vol. i, pp. 12, 13; also, pp. 99 *et seq.* For germs among thinkers of India, see Whewell, vol. i, p. 277; also, Whitney, Oriental and Linguistic Studies, New York, 1874; Essay on the Lunar Zodiac, p. 345. For the views of Vincent de Beauvais, see his Speculum Naturale, edition of 1480, lib. xvi, cap 21. For Cardinal d'Ailly's view, see his Ymago Mundi, 1490, treatise De Concordia Astronomicæ Veritatis cum Theologia.

For general statement of De Cusa's work, see Draper, Intellectual Development of Europe, p. 512. For skillful use of De Cusa's view in order to mitigate censure upon the Church for its treatment of Copernicus's discovery, see an article in the Catholic World for January, 1869. For a very exact statement, in a spirit of judicial fairness, see Whewell, History of the Inductive Sciences, p. 275 and pp. 379, 380. In the latter, Whewell cites the exact words of De Cusa in the De Docta Ignorantia, and sums up in these words: "This train of thought might be a preparation for the reception of the Copernican system; but it is very different from the doctrine that the sun is the center of the planetary system." Whewell says: "De Cusa propounded the doctrine of the motion of the earth more as a paradox than a reality. We can not consider this as any distinct anticipation of a profound and consistent view of the truth." On De Cusa, see also Heller, vol. i, p. 216. For Aristotle's views, and their elaboration by St. Thomas Aquinas, see the De Cœlo et Mundo, sec. xx, and elsewhere in the latter. It is curious to see how even such a biographer as Archbishop Vaughan slurs over the angelic doctor's errors. See Vaughan's Life and Labors of St. Thomas of Aquin, pp. 459, 460.

Copernicus's Danger at Rome.—The Catholic World for January, 1869, cites a speech of the Archbishop of Mechlin, before the University of Louvain, to the effect that Copernicus defended his theory at Rome, in 1500, before two thousand scholars; also, that another professor taught the system in 1528, and was made apostolic notary by Clement VIII. All this, even if the doctrines taught were identical with those of Copernicus, as finally developed, which is simply not the case, avails nothing against the overwhelming testimony that Copernicus felt himself in danger—testimony which the after-history of the Copernican theory renders invincible. The very title of Fromundus's book, already cited, published within a few miles of the archbishop's own cathedral, and sanctioned expressly by the theological faculty of that same University of Louvain in 1630, utterly refutes the archbishop's idea that the Church was inclined to treat Copernicus kindly.

But Osiander's courage fails him: he dares not launch the new thought boldly. He writes a groveling preface, endeavoring to excuse Copernicus for his novel idea, and in this he inserts the apologetic lie that Copernicus propounds the doctrine of the earth's movement not as a fact, but as a hypothesis; he declares that it is lawful for an astronomer to indulge his imagination, and that this is what Copernicus has done.

Thus was the greatest and most ennobling, perhaps, of scientific truths—a truth not less ennobling to religion than to science—forced in coming before the world to sneak and crawl.*

On the 24th of May, 1543, the newly printed book arrived at the house of Copernicus. It was put into his hands; but he was on his death-bed. A few hours later he was beyond the reach of the conscientious men who would have blotted his reputation, and perhaps have destroyed his life.

Yet not wholly beyond their reach. Even death could not be trusted to shield him. There seems to have been fear of vengeance upon his corpse, for on his tombstone was placed no record of his life-long labors, no mention of his great discovery; but there was graven upon it simply a prayer: "I ask not the grace accorded to Paul; not that given to Peter; give me only the favor

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The title is as follows: "Anti-Aristarchus sive Orbis-Terræ Immobilis in quo decretum S. Congregationis S. R. E. Cardinalium I.QC.XVI adversus Pythagorico-Copernicanos editum defenditur, Antwerpiæ, MDCXXXI." L'Epinois, Galilée, Paris, 1867, lays stress, p. 14, on the broaching of the doctrine by De Cusa, in 1435, and by Widmanstadt in 1533, and their kind treatment by Eugenius IV and Clement VII, but this is absolutely worthless in denying the papal policy afterward. Lange, Geschichte des Materialismus, vol. i, pp. 217, 218, while admitting that De Cusa and Widmanstadt sustained this theory, and received honors from their respective popes, shows that, when the Church gave it serious consideration, it was condemned. There is nothing in this view unreasonable. It would be a parallel case to that of Leo X, at first inclined toward Luther and others, in their "squabbles with the begging friars," and afterward forced to oppose them. That Copernicus felt the danger is evident, among other things, by the expression in the preface: "*Statim me explodendum cum tali opinione clamitant.*" For dangers at Wittenberg, see Lange, Geschichte des Materialismus, vol. i, p. 217.

* Osiander, in a letter to Copernicus, dated April 20, 1541, had endeavored to reconcile him to such a procedure, and ends by saying, "Sic enim placidiores reddideris peripatheticos et theologos quos contradicturos metuis." See Apologia Tychonis in Kepleri Opera Omnia, Frisch's edition, vol. i, p. 246. Kepler holds Osiander entirely responsible for this preface. Bertrand, in his Fondateurs de l'Astronomie moderne, gives its text, and thinks it possible that Copernicus may have yielded "in pure condescension toward his disciple." But this idea is utterly at variance with expressions in Copernicus's own dedicatory letter to the Pope, which follows the preface. For a good summary of the argument, see Figuier, Savants de la Renaissance, pp. 378, 379; see, also, citation from Gassendi's Life of Copernicus, in Flammarion, Vie de Copernic, p. 124. Mr. John Fiske, accurate as he usually is, in his Outlines of Cosmic Philosophy, appears to have followed Laplace, Delambre, and Petit into the error of supposing that Copernicus, and not Osiander, is responsible for the preface. For the latest proofs, see Menzer's translation of Copernicus's work, Thorn, 1879, notes on pp. 3 and 4 of the appendix.

which Thou didst show to the thief on the cross." Not till thirty years after did a friend dare write on his tombstone a memorial of his discovery.*

The preface of Osiander, pretending that the book of Copernicus suggested a hypothesis instead of announcing a truth, served its purpose well as regards the book itself. During nearly seventy years the Church authorities evidently thought it best not to stir the matter, and in some cases professors like Calganini were allowed to present the new view purely as a hypothesis. There were, indeed, mutterings from time to time on the theological side, but there was no great demonstration against the system until 1616. Then, when the Copernican doctrine was upheld by Galileo as a *truth*, and proved to be a truth by his telescope, the book was taken in hand by the Roman curia. The statements of Copernicus were condemned "until they should be corrected," and the corrections required were simply such as would substitute for his conclusions the old Ptolemaic theory.

That this was their purpose was seen in that year when Galileo was forbidden to teach or discuss the Copernican theory, and when were forbidden "all books which affirm the motion of the earth." Henceforth to read the work of Copernicus was to risk damnation, and the world accepted the decree.†

There was, indeed, in Europe one man who might have done much to check this current of unreason which was to sweep away so many thoughtful men on the one hand from scientific knowledge, and so many on the other from Christianity. This

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* See Figuier, Savants de la Renaissance, p. 380; also, Flammarion, Vie de Copernic, p. 190.

† The authorities deciding this matter in accordance with the wishes of Pope Paul V and Cardinal Bellarmine were the Congregation of the Index, or cardinals having charge of the Index Librorum Prohibitorum. Recent desperate attempts to fasten the responsibility on them as individuals seem ridiculous in view of the simple fact that their work was sanctioned by the highest Church authority, and required to be universally accepted by the Church. Eleven different editions of the Index in my own possession prove this. Nearly all of these declare on their title-pages that they are issued by order of the pontiff of the period, and each is prefaced by a special papal bull or letter. See especially the Index of 1664, issued under order of Alexander VII, and that of 1761, under Benedict XIV. Copernicus's statements were prohibited in the Index "*donec corrigantur.*" Kepler said that it ought to be worded "*donec explicetur.*" See Bertrand, Fondateurs de l'Astronomie moderne, page 57. De Morgan, pages 57–60, gives the corrections required by the Index of 1620. Their main aim seems to be to reduce Copernicus to the groveling level of Osiander, making of his discovery a mere hypothesis; but occasionally they require a virtual giving up of the whole Copernican doctrine—e. g., "correction" insisted upon for chapter viii, p. 6. For a scholarly account of the relation of the Prohibitory and Expurgatory Indexes to each other, see Mendham, Literary Policy of the Church of Rome; also, Reusch, Index der verbotenen Bücher, Bonn, 1855, vol. ii, chaps. i and ii. For a brief but very careful statement, see Gebler, Galileo Galilei, English translation, London, 1879, chap. i; see, also, Addis and Arnold's Catholic Dictionary, article Galileo, p. 8.

was Peter Apian. He was one of the great mathematical and astronomical scholars of the time. His brilliant abilities had made him the astronomical teacher of the Emperor Charles V; his work on geography had brought him a world-wide reputation; his work on astronomy brought him a patent of nobility; his improvements in mathematical processes and astronomical instruments brought him the praise of Kepler and a place in the history of science: never had a true man a better opportunity to do a great deed. When Copernicus's work appeared, Apian was at the height of his reputation and power: a quiet, earnest plea from him, even if it had been only for ordinary fairness and a suspension of judgment, must have carried much weight. His devoted pupil, Charles V, who sat on the thrones of Germany and Spain, must at least have given a hearing to such a plea. But, unfortunately, Apian was a professor in an institution of learning under the strictest Church control—the University of Ingolstadt. His foremost duty was to teach *safe* science—to keep science within the line of scriptural truth as interpreted by theological professors. His great opportunity was lost. Apian continued to maunder over the Ptolemaic theory and astrology in his lecture-room. As to the attacks on the Copernican theory, he neither supported nor opposed them; he was silent; and the cause of his silence should never be forgotten so long as any church asserts its title to control university instruction.*

Doubtless, many will exclaim against the Roman Catholic Church for this; but the simple truth is that Protestantism was no less zealous against the new scientific doctrine. All branches of the Protestant Church—Lutheran, Calvinist, Anglican—vied with each other in denouncing the Copernican doctrine as contrary to Scripture; and, at a later period, the Puritans showed the same tendency.

Said Martin Luther: "People gave ear to an upstart astrologer who strove to show that the earth revolves, not the heavens or the firmament, the sun and the moon. Whoever wishes to appear clever must devise some new system, which of all systems is of course the very best. This fool wishes to reverse the entire science of astronomy; but sacred Scripture tells us that Joshua commanded the sun to stand still and not the earth." Melanchthon, mild as he was, was not behind Luther in condemning Copernicus. In his treatise on the Elements of Physics, published six years after Copernicus's death, he says: "The eyes are witnesses that the heavens revolve in the space of twenty-four

* For Peter Apian, see Mädler, Geschichte der Astronomie, Braunschweig, 1873, vol. i, p. 141. For evidences of the special favor of Charles V, see Delambre, Histoire de l'Astronomie du Moyen Age, p. 390; also Brühns, in the Allgemeine deutsche Biographie. For an attempted apology for him, see Günther, Peter and Philipp Apian, Prag, 1882, p. 62.

hours. But certain men, either from the love of novelty, or to make a display of ingenuity, have concluded that the earth moves; and they maintain that neither the eighth sphere nor the sun revolves. . . . Now, it is a want of honesty and decency to assert such notions publicly, and the example is pernicious. It is the part of a good mind to accept the truth as revealed by God and to acquiesce in it." Melanchthon then cites passages from the Psalms and from Ecclesiastes, which he declares assert positively and clearly that the earth stands fast, and that the sun moves around it, and adds eight other proofs of his proposition that "the earth can be nowhere if not in the center of the universe." So earnest does this mildest of the Reformers become, that he suggests severe measures to restrain such impious teachings as those of Copernicus.*

While Lutheranism was thus condemning the theory of the earth's movement, other branches of the Protestant Church did not remain behind. Calvin himself took the lead, in his Commentary on Genesis, by condemning all who asserted that the earth is not at the center of the universe. "Who," he said, "will venture to place the authority of Copernicus above that of the Holy Spirit?" Turretin, Calvin's famous successor, even after Kepler and Newton had virtually completed the theory of Copernicus and Galileo, put forth his compendium of theology, in which he proved, from a multitude of scriptural texts, that the heavens, sun, and moon move about the earth, which stands still in the center. In England we see similar theological efforts, even after they had become evidently hopeless. Hutchison's Moses' Principia, Dr. Samuel Pikes's Sacred Philosophy, the writings of Bishop Horne, Bishop Horsely, and President Forbes contain most earnest attacks upon the ideas of Newton; such attacks being based upon Scripture. Dr. John Owen, so famous in the annals of Puritanism, declared the Copernican system a "delusive and arbitrary hypothesis, contrary to Scripture"; and even John Wesley declared the new ideas to tend toward "infidelity."†

And Protestant peoples were not a whit behind Catholic in following out such teachings. The people of Elbing made them-

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* See the Walsch edition of Luther's works, 1743, p. 2260; also the Tischreden; also Melanchthon's Initia Doctrinæ Physicæ. This treatise is cited under a mistaken title by the Catholic World, September, 1870. The correct title is as given above; it will be found in the Corpus Reformatorum, ed. Bretschneider, Halle, 1846. (For the above passage see vol. xiii, pp. 216, 217; also, Mädler, vol. i, p. 176; also, Lange, Geschichte des Materialismus, vol. i, p. 217; also, Prowe, Ueber die Abhängigkeit des Copernicus, Thorn, 1865, p. 4; also note, pp. 5, 6, where text is given in full.)

† On the Teachings of Protestantism as regards the Copernican theory, see citations in Canon Farrar's History of Interpretation, preface, xviii; also, Rev. Dr. Shields, of Princeton, The Final Philosophy, pp. 60, 61.

selves merry over a farce in which Copernicus was the main object of ridicule. The people of Nuremberg, a Protestant stronghold, caused a medal to be struck with inscriptions ridiculing the philosopher and his theory.

Why the people at large took this view is easily understood when we note the attitude of the guardians of learning, both Catholic and Protestant, in that age. It throws great light upon sundry claims by modern theologians to take charge of public instruction and of the evolution of science. So important was it thought to have "sound learning" guarded, and "safe science" taught, that in many of the universities, as late as the end of the seventeenth century, professors were forced to take an oath not to hold the "Pythagorean"—that is, the Copernican idea—as to the movement of the heavenly bodies. As the contest went on, professors were forbidden to make known to students the facts revealed by the telescope. Special orders to this effect were issued by the ecclesiastical authorities to the universities and colleges of Pisa, Innspruck, Louvain, Douay, Salamanca, and others; during generations we find the authorities of these universities boasting that these godless doctrines were kept away from their students. It is touching to hear such boasts made then, just as it is touching now to hear sundry excellent university authorities boast that they discourage the reading of Mill, Spencer, and Darwin. Nor were such attempts to keep the truth from students confined to the Roman Catholic institutions of learning. Strange as it may seem, nowhere were the facts confirming the Copernican theory more carefully kept out of sight than at Wittenberg; the university of Luther and Melanchthon. About the middle of the sixteenth century there were at that center of Protestant instruction two astronomers of a very high order, Rheticus and Reinhold: both of these, after thorough study, had convinced themselves that the Copernican system was true, but neither of them was allowed to tell this truth to his students. Neither in his lecture announcements nor in his published works did Rheticus venture to make the new system known, and he at last gave up his professorship and left Wittenberg, that he might have freedom to seek and tell the truth. Reinhold was even more wretchedly humiliated. Convinced of the truth of the new theory, he was obliged to advocate the old; if he mentioned the Copernican ideas, he was compelled to overlay them with the Ptolemaic. Even this was not thought safe enough, and in 1571 the subject was intrusted to Peucer. He was eminently "sound," and denounced the Copernican theory in his lectures as "absurd and unfit to be introduced into the schools."

To clinch anti-scientific ideas more firmly into German Protestant teaching, Rector Hensel wrote a text-book for schools en-

titled "The Restored Mosaic System of the World," which showed the Copernican astronomy to be unscriptural.

Doubtless this has a far-off sound; yet its echo comes very near modern Protestantism in the expulsion of Dr. Woodrow by the Presbyterian authorities in South Carolina; the expulsion of Prof. Winchell by the Methodist Episcopal authorities of Tennsesee; the expulsion of Prof. Toy by the authorities of another Protestant sect in Kentucky; the expulsion of the professors at Beyrout under authority of the American Board of Commissioners for Foreign Missions—all for holding the doctrines of modern science, and in the last years of the nineteenth century.

When Protestants talk of the "bigotry" of the Roman Catholic Church, they will do well to remember that it is impossible to imagine such Catholic authorities as Cardinal Gibbons, Archbishops Ireland and Kenrick, and Bishops Keane and Spalding, sanctioning such suicidal folly as this. The Mother Church has learned something.*

But the new truth could not be concealed; it could neither be laughed down nor frowned down. Many minds had received it, but within the hearing of the papacy only one tongue appears to have dared to utter it clearly. This new warrior was that strange mortal, Giordano Bruno. He was hunted from land to land, until at last he turned on his pursuers with fearful invectives. For this he was imprisoned during six years, then burned alive, and his ashes scattered to the winds.† Still, the new truth lived on. Ten years after the martydom of Bruno the truth of Copernicus's doctrine was established by the telescope of Galileo.

Herein was fulfilled one of the most touching of prophecies. Years before, the opponents of Copernicus had said to him, "If your doctrines were true, Venus would show phases like the moon." Copernicus answered: "You are right; I know not what to say; but God is good, and will in time find an answer to this objection." The God-given answer came when in 1611 the rude telescope of Galileo showed the phases of Venus.‡

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* For treatment of Copernican ideas by the people, see The Catholic World, as above; also, Melanchthon, *ubi supra*; also, Prowe, Copernicus, Berlin, 1883, vol. i, p. 269, note; also, pp. 279, 280; also Mädler, i, p. 167. For Rector Hensel, see Rev. Dr. Shield's Final Philosophy, p. 60. For details of recent Protestant efforts against evolution doctrines, see my chapter on The Fall of Man and Anthropology, in this series.

† For Bruno, see Bartholmess, Vie de Jordano Bruno, Paris, 1846, vol. i, p. 121 and pp. 212 *et seq.*; also Berti, Vita di Giordano Bruno, Firenze, 1868, chapter xvi; also Whewell, vol. i, pp. 272, 273. That Whewell is somewhat hasty in attributing Bruno's punishment entirely to the Spaccio della Bestia Trionfante will be evident, in spite of Montucla, to any one who reads the account of the persecution in Bartholmess or Berti; and, even if Whewell be right, the Spaccio would never have been written but for Bruno's indignation at ecclesiastical oppression. See Tiraboschi, vol. vii, pp. 466 *et seq.*

‡ For the relation of these discoveries to Copernicus's work, see Delambre, Histoire de

On this new champion, Galileo, the whole war was at last concentrated. His discoveries had clearly taken the Copernican theory out of the list of hypotheses, and had placed it before the world as a truth. Against him, then, the war was long and bitter. The supporters of what was called "sound learning" declared his discoveries deceptions and his announcements blasphemy. Semi-scientific professors, endeavoring to curry favor with the Church, attacked him with sham science; earnest preachers attacked him with perverted Scripture; theologians, inquisitors, congregations of cardinals, and at last two popes dealt with him, and, as was supposed, silenced his impious doctrine forever.*

I shall present this warfare at some length because, so far as I can find, no careful summary of it has been given in our language, since the whole history was placed in a new light by the revelations of the trial documents in the Vatican Library, honestly published for the first time by M. L'Epinois, in 1867, and since that by Gebler, Berti, Favaro, and others.

The first important attack on Galileo began in 1610, when he announced that his telescope had revealed the moons of the planet Jupiter. The enemy saw that this took the Copernican theory out of the realm of hypothesis, and they gave battle immediately. They denounced both his method and its results as absurd and impious. As to his method, professors bred in the "safe science" favored by the Church argued that the only way of studying the universe was by comparing texts of Scripture; and, as to his results, they insisted, first, that Aristotle knew nothing of these new revelations; and, next, that the Bible showed by all applicable types that there could be only seven planets; that this was proven by the seven golden candlesticks of the Apocalypse, by the seven-branched candlestick of the tabernacle, and by the seven churches of Asia; that from Galileo's doctrine consequences must logically result destructive to Christian truth: bishops and priests therefore warned their flocks, and multitudes of the faithful besought the Inquisition to deal speedily and sharply with the heretic.†

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l'Astronomie Moderne, discours préliminaire, p. xiv; also Laplace, Système du Monde, vol. i, p. 326; and for more careful statements, Kepleri Opera Omni, edit. Frisch., tome ii, p. 464. For Copernicus's prophecy, see Cantu, Histoire Universelle, vol. xv, p. 473 (Cantu is an eminent Roman Catholic).

* A very curious example of this sham science employed by theologians is seen in the argument, frequently used at that time, that, if the earth really moved, a stone falling from a height would fall back of the point immediately below its point of starting. This is used by Fromundus with great effect. It appears never to have occurred to him to test the matter by dropping a stone from the topmast of a ship; Benzenburg has experimentally demonstrated just such an aberration in falling bodies as is mathematically required by the diurnal motion of the earth. See Jevons, Principles of Science, pp. 388, 389, in one volume, second edition, 1877.

† See Delambre on the discovery of the satellites of Jupiter as the turning-point with

In vain did Galileo try to prove the existence of satellites by showing them to the doubters through his telescope: they either declared it impious to look, or, if they did look, denounced the satellites as illusions from the devil. Good Father Clavius declared that "to see satellites of Jupiter, men had to make an instrument which would create them." In vain did Galileo try to save the great truths he had discovered by his letters to the Benedictine Castelli and the Grand Duchess Christine, in which he argued that literal biblical interpretation should not be applied to science; it was answered that such an argument only made his heresy more detestable; that he was "worse than Luther or Calvin."

The war on the Copernican theory, which up to that time had been carried on quietly, now flamed forth. It was declared that the doctrine was proved false by the standing still of the sun for Joshua, by the declarations that "the foundations of the earth are fixed so firm that they can not be moved," and that the sun "runneth about from one end of the heavens to the other." *

But the little telescope of Galileo still swept the heavens, and another revelation was announced—the mountains and valleys in the moon. This brought on another attack. It was declared that this, and the statement that the moon shines by light reflected from the sun, directly contradict the statement in Genesis that the moon is "a great light." To make the matter worse, a painter, placing the moon in a religious picture in its usual position beneath the feet of the Blessed Virgin, outlined on its surface mountains and valleys; this was denounced as a sacrilege logically resulting from the astronomer's heresy.

Still another struggle was aroused when the hated telescope revealed spots upon the sun, and their motion indicating the sun's rotation. Monsignor Elci, head of the University of Pisa, forbade the astronomer Castelli to mention these spots to his students. Father Busaeus, at the University of Innspruck, forbade

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the heliocentric doctrine. As to its effects on Bacon, see Jevons, Principles of Science, p. 638, as above. For argument drawn from the candlestick and seven churches, see Delambre, p. 20.

* For principal points as given, see Libri, Histoire des Sciences mathématiques en Italie, vol. iv, p. 211; De Morgan, Paradoxes, p. 26, for account of Father Clavius. It is interesting to know that Clavius, in his last years, acknowledged that "the whole system of the heavens is broken down, and must be mended." Cantu, Histoire Universelle, vol. xv, p. 478. See Th. Martin, Galilée, pp. 34, 208, and 266; also Heller, Geschichte der Physik, Stuttgart, 1882, vol. i, p. 366. For the original documents, see L'Epinois, pp. 34 and 36. Martin's translation seems somewhat too free. See also, Gebler, Galileo Galilei, English translation, London, 1879, pp. 76–78; also Gebler, Acten des Galileischen Process, for careful copies of the documents; also Reusch, Der Process Galilei's und die Jesuiten, Bonn, 1879, chapters ix, x, xi. See also full official text in L'Epinois, and also the extract given by Gebler, Galileo Galilei, p. 78.

the astronomer Scheiner, who had also discovered the spots and proposed a *safe* explanation of them, to allow the new discovery to be known there. At the College of Douay and the University of Louvain this discovery was expressly placed under the ban, and this became the general rule among the Catholic universities and colleges of Europe. The Spanish universities were especially intolerant of this and similar ideas, and up to a recent period they were strictly forbidden in the most important university of all—that of Salamanca.*

Such are the consequences of placing the instruction of men's minds in the hands of those mainly absorbed in saving men's souls. Nothing could be more in accordance with the idea recently put forth by sundry ecclesiastics, Catholic and Protestant, that the Church alone is empowered to promulgate scientific truth or direct university instruction. But science gained the victory here also. Observations of the solar spots were reported not only from Galileo, in Italy, but from Fabricius, in Holland. Father Scheiner then endeavored to make the usual compromise between theology and science. He promulgated a pseudo-scientific theory, which only provoked derision.

The war became more and more bitter. The Dominican father, Caccini, preached a sermon from the text, "Ye men of Galilee, why stand ye gazing up into heaven?" and this wretched pun upon the great astronomer's name ushered in sharper weapons; for, before Caccini ends, he insists that "geometry is of the devil," and that "mathematicians should be banished as the authors of all heresies." The church authorities gave Caccini promotion.

Father Lorini proved that Galileo's doctrine was not only heretical but "atheistic," and besought the Inquisition to intervene. The Bishop of Fiesole screamed in rage against the Copernican system, publicly insulted Galileo, and denounced him to the grand duke. The Archbishop of Pisa secretly sought to entrap Galileo and deliver him to the Inquisition at Rome. The Archbishop of Florence solemnly condemned the new doctrines as unscriptural; and Paul V, while petting Galileo, and inviting him as the greatest astronomer of the world to visit Rome, was secretly moving the Archbishop of Pisa to pick up evidence against the astronomer.

But by far the most terrible champion who appeared against the new astronomy was Cardinal Bellarmin, one of the greatest theologians the world has known. He was earnest, sincere, and learned, but insisted on making science conform to Scripture. The weapons which men of Bellarmin's stamp used were purely theological. They held up before the world the dreadful conse-

* See Ticknor, History of Spanish Literature, vol. iii.

quences which must result to Christian theology were the heavenly bodies proved to revolve about the sun and not about the earth. Their most tremendous engine against Galileo was the statement that "his pretended discovery vitiates the whole Christian plan of salvation." Father Lecazre declared that "it casts suspicion on the doctrine of the incarnation." Others declared that it "upsets the whole basis of theology; that if the earth is a planet, and only one among several planets, it can not be that any such great things have been done specially for it as the Christian doctrine teaches. If there are other planets, since God makes nothing in vain, they must be inhabited; but how can these inhabitants be descended from Adam? How can they trace back their origin to Noah's ark? How can they have been redeemed by the Saviour?" Nor was this argument confined to the theologians of the Roman Church; Melanchthon, Protestant as he was, had already used it in his attacks on Copernicus and his school.

In addition to this prodigious theological engine of war there was kept up a fire of smaller artillery in the shape of texts and scriptural extracts.

But the war grew still more bitter, and some weapons used in it are worth examining. They are very easily examined, for they are to be found on all the battle-fields of science; but on that field they were used with more effect than on almost any other. These weapons are the epithets "infidel" and "atheist." The battle-fields of science are thickly strewn with these. They have been used against almost every man who has ever done anything new for his fellow-men. The list of those who have been denounced as "infidel" and "atheist" includes almost all great men of science, general scholars, inventors, and philanthropists. The purest Christian life, the noblest Christian character, have not availed to shield combatants. Christians like Isaac Newton, Pascal, Locke, Milton, and even Fénelon and Howard, have had this weapon hurled against them. Of all proofs of the existence of a God, those of Descartes have been wrought most thoroughly into the minds of modern men; yet the Protestant theologians of Holland sought to bring him to torture and to death by the charge of atheism, and the Roman Catholic theologians of France prevented any due honors to him at his burial.*

These epithets can hardly be classed with civilized weapons. They are burning arrows; they set fire to masses of popular prejudice, always obscuring the real question, sometimes destroy-

* For various objectors and objections to Galileo by his contemporaries, see Libri, Histoire des Sciences mathématiques en Italie, vol. iv, pp. 233, 234; also Martin, Vie de Galilée. For Father Lecazre's argument, see Flammarion, Mondes imaginaires et réels, 6ième édition, pp. 315, 316. For Melanchthon's argument, see his Initia, in Opera, vol. iii, Halle, 1846.

ing the attacking party. They are poisoned weapons. They pierce the hearts of loving women; they alienate dear children; they injure man after life is ended, for they leave poisoned wounds in the hearts of those who loved him best—fears for his eternal salvation, dread of the divine wrath upon him. Of course, in these days these weapons, though often effective in vexing good men and in scaring good women, are somewhat blunted; indeed, they not infrequently injure the assailants more than the assailed. So it was not in the days of Galileo; they were then in all their sharpness and venom.* Yet worse even than these weapons was the attack by the Archbishop of Pisa.

This man, whose cathedral derives its most enduring fame from Galileo's deduction of a great natural law from the swinging lamp before its altar, was not an archbishop after the noble mold of Borromeo and Fénelon and Cheverus. He was, sadly enough for the Church and humanity, simply a zealot and intriguer: he perfected the plan for entrapping the great astronomer.

Galileo, after his discoveries had been denounced, had written to his friend Castelli and to the Grand Duchess Christine two letters to show that his discoveries might be reconciled to Scripture. On a hint from the Inquisition at Rome, the archbishop sought to get hold of these letters and exhibit them as proofs that Galileo had uttered heretical views of theology and of Scripture, and thus to bring him into the clutch of the Inquisition. The archbishop begs Castelli, therefore, to let him see the original letter in the handwriting of Galileo. Castelli declines; the archbishop then, while, as is now revealed, writing constantly and bitterly to the Inquisition against Galileo, professes to Castelli the greatest admiration of Galileo's genius and a sincere desire to know more of his discoveries. This not succeeding, the archbishop at last throws off the mask and resorts to open attack.

The whole struggle to crush Galileo and to save him would be amusing were it not so fraught with evil. There were intrigues and counter-intrigues, plots and counter-plots, lying and spying; and, in the thickest of this seething, squabbling, screaming mass of priests, bishops, archbishops, and cardinals, strove two popes, Paul V and Urban VIII. It is most suggestive to see in this crisis of the Church, at the tomb of the prince of the apostles, on the eve of the greatest errors in church policy the world has known, in all the intrigues and deliberations of these consecrated

* For curious exemplification of the way in which these weapons have been hurled, see lists of persons charged with "infidelity" and "atheism," in Le Dictionnaire des Athées, Paris, An. viii; also Lecky, History of Rationalism, vol. ii, p. 50. For the case of Descartes, see Saisset, Descartes et ses Précurseurs, pp. 103, 110.

leaders of the Church, no more evidence of the guidance or presence of the Holy Spirit than in a caucus of New York politicians at Tammany Hall.

But the opposing powers were too strong: in 1615 Galileo was summoned before the Inquisition at Rome, and the mine which had been so long preparing was sprung. Sundry theologians of the Inquisition having been ordered to examine two propositions which had been extracted from Galileo's letters on the solar spots, solemnly considered these points during about a month and rendered their unanimous decision as follows: "*The first proposition, that the sun is the center and does not revolve about the earth, is foolish, absurd, false in theology, and heretical, because expressly contrary to Holy Scriptures*"; and "*the second proposition, that the earth is not the center but revolves about the sun, is absurd, false in philosophy, and, from a theological point of view at least, opposed to the true faith.*"

The Pope himself, Paul V, now intervened again: he ordered that Galileo be brought before the Inquisition. Then the greatest man of science in that age was brought face to face with the greatest theologian—Galileo was confronted by Bellarmin. Bellarmin shows Galileo the error of his opinion and orders him to renounce it. De Lauda, fortified by a letter from the Pope, gives orders that the astronomer be placed in the dungeons of the Inquisition should he refuse to yield. Bellarmin now commands Galileo, "in the name of his Holiness the Pope and the whole Congregation of the Holy Office, to relinquish altogether the opinion that the sun is the center of the world and immovable, and that the earth moves, nor henceforth to hold, teach, or defend it in any way whatsoever, verbally or in writing." This injunction Galileo acquiesces in and promises to obey.*

This was on the 26th of February, 1616. About a fortnight later the Congregation of the Index, moved thereto, as the letters and documents now brought to light show, by Pope Paul V, solemnly rendered a decree that "*the doctrine of the double motion of the earth about its axis and about the sun* is false and entirely contrary to *Holy Scripture*"; and that this opinion must neither be taught nor advocated. The same decree condemned all writings of Copernicus and "*all writings which affirm the motion of the earth.*" The great work of Copernicus was interdicted until corrected in accordance with the views of the Inquisition; and the works of Galileo and Kepler, though not mentioned by name at

* I am aware that the theory proposed by Wohlwill and developed by Gebler denies that this injunction and promise were ever made by Galileo, and holds that the passage was a forgery devised later by the Church rulers to justify the proceedings of 1632 and 1633. This would make the conduct of the Church worse, but the better authorities consider the charge not proved. A careful examination of the documents seems to disprove it.

that time, were included among those implicitly condemned as "affirming the motion of the earth."

The condemnations were inscribed upon the Index; and, finally, the papacy committed itself as a judge and teacher to the world by prefixing to the Index the usual papal bull giving its monitions the most solemn papal sanction. To teach or even read the works denounced or passages condemned was to risk persecution in this world and damnation in the next. Science had apparently lost the decisive battle.

For a time after this judgment Galileo remained in Rome, apparently hoping to find some way out of this difficulty; but he soon discovered the hollowness of the protestations made to him by ecclesiastics, and, being recalled to Florence, remained in his hermitage near the city in silence, working steadily, indeed, but not publishing anything save by private letters to friends in various parts of Europe.

But at last a better vista seemed to open before him. Cardinal Barberini, who had seemed liberal and friendly, became pope under the name of Urban VIII. Galileo at this conceived new hopes, and allowed his continued allegiance to the Copernican system to be known. New troubles ensued. Galileo was induced to visit Rome again, and Pope Urban tried to cajole him into silence, personally taking the trouble to show him his errors by argument. Other opponents were less considerate, for works appeared attacking his ideas—works all the more unmanly, since their authors knew that Galileo was restrained by force from defending himself. Then, too, as if to accumulate proofs of the unfitness of the Church to take charge of advanced instruction, his salary as a professor at the University of Pisa was taken from him, and sapping and mining began. Just as the Archbishop of Pisa some years before had tried to betray him with honeyed words to the Inquisition, so now Father Grassi tried it, and, after various attempts to draw him out by flattery, suddenly denounced his scientific ideas as "leading to a denial of the real presence in the eucharist."

For the final assault upon him a park of heavy artillery was at last wheeled into place. It may be seen on all the scientific battle-fields. It consists of general denunciation; and in 1631 Father Melchior Inchofer, of the Jesuits, brought his artillery to bear upon Galileo with this declaration: "The opinion of the earth's motion is of all heresies the most abominable, the most pernicious, the most scandalous; the immovability of the earth is thrice sacred; argument against the immortality of the soul, the existence of God, and the incarnation, should be tolerated sooner than an argument to prove that the earth moves."

From the other end of Europe came a powerful echo. From

the shadow of the Cathedral of Antwerp, the noted theologian, Fromundus, gave forth his famous treatise, the Anti-Aristarchus. Its very title-page was a contemptuous insult to the memory of Copernicus, since it paraded the assumption that the new truth was only an exploded theory of a pagan astronomer. Fromundus declares that "sacred Scripture fights against the Copernicans." To prove that the sun revolves about the earth he cites the passage in the Psalms which speaks of the sun "which cometh forth as a bridegroom out of his chamber." To prove that the earth stands still, he quotes a passage from Ecclesiastes, "The earth standeth fast forever." To show the utter futility of the Copernican theory, he declares that if it were true, "the wind would constantly blow from the east"; and that "buildings and the earth itself would fly off with such a rapid motion that men would have to be provided with claws like cats to enable them to hold fast to the earth's surface." Greatest weapon of all, he works up, by the use of Aristotle and St. Thomas Aquinas, a demonstration from theology and science combined, that the earth *must* stand in the center, and that the sun *must* revolve about it.*

DOMESTIC ANIMALS IN INDIA.†

By JOHN LOCKWOOD KIPLING.

PASSING from the free to the fettered, we come to a beast which in India serves at once as an expression of wild liberty, more complete than that of the monkey, and of utter and abject slavery. For a wholly unmerited obloquy, relic of a dark aboriginal superstition, is added to the burden of toil and hard living. Yet there was once a time when in the nearer East, or ever the horse was known, he was held in high honor, carved in Assyrian sculptures, and reckoned a suitable steed for prophets and kings. Even now, in Cairo, Damascus, and Bagdad, although the Bedawi Arab pretends to despise him, he is regularly ridden by respectable people.

* For Father Inchofer's attack, see his Tractatus Syllepticus, cited in Galileo's letter to Deodati, July 28, 1634. For Fromundus's more famous attack see his Anti-Aristarchus, already cited, *passim*, but especially the heading of chapter vi, and the argument in chapters x and xi. A copy of this work may be found in the Astor Library at New York, and another in the White Library at Cornell University. For interesting reference to one of Fromundus's arguments, showing, by a mixture of mathematics and theology, that the earth is the center of the universe, see Quetelet, Histoire des Sciences mathématiques et physiques, Bruxelles, 1864, p. 170; also Mädler, Geschichte der Astronomie, vol. i, p. 274.

† Extracted from the author's recent book, Beast and Man in India, by the courtesy of the publishers, Messrs. Macmillan & Co.

The Arabian Nights story of a conversation overheard between the ox and the ass shows the estimation in which he was held; and it is written that Mohammed himself had two asses, one of which was called Yafūr, nor did that great man disdain to ride double. But here in India, by formal prescription, only the gypsy, the potter, the washerman, and such-like folk, out-caste or of low caste, will mount or own the ass. This prescription,

FIG. 1.—THE POTTER AND HIS DONKEY.

and the ridiculous Hindu association of the donkey with the goddess of small-pox, account for the universal dislike and disdain in which this most useful, sagacious, and estimable animal is held. He is never fed by his owners, and his chronic hunger is mocked by a popular saying that to feed a donkey is neither sin nor sacrifice.

It would seem difficult to be cruel to a goat, but the keepers of the flocks of milch-goats regularly driven morning and evening into Indian cities contrive to inflict a good deal of pain. The nipples of the udder are tied up in torturing fashion, and there is an unnecessary use of the staff. But the worst cruelty is the practice of flaying them alive, in the belief that skins thus prepared have a better quality. The magistrates in the Presidency towns

frequently have cases of this offense before them, and inflict absurdly inadequate fines.

A quaint belief is that in dry desert places where wells formerly existed goats will group themselves in a circle round the ancient well-brink, though not a trace of it is visible to the keen-

FIG. 2.—MILCH GOATS.

est human eye. Those who sketch animals may have noticed that goats at rest have a way of grouping themselves as if posing for their portraits. It is possible that this unconscious trick is at the bottom of the well-brink belief. So far as I know, there are no sayings which notice the fine carriage of the head and the elegant horse-like gait of this beautiful animal. The Indian goat, as a rule, is much taller and of more slender build than the European animal.

FIG. 3.—A SPORTING MAN.

From an administrative and economic point of view there are serious objections to the goat, which is one of the plagues of the Forest Department of the Government. It is the poor man's animal, and is supposed to cost nothing to keep. Every green shoot is nibbled off as soon as it peeps above the ground, and young trees are promptly destroyed by creatures which spend half their time on their hind legs, and have an effective reach up to the height of a man's head.

It is only in India and Peru that the sheep is used as a beast of burden. Borax, asafœtida, and other commodities are brought in bags on the backs of sheep driven in large flocks from Thibet into British territory. Only the picturesque shepherds return from these journeys ; for the carriers of the caravan, feeding as they go, gather flesh in spite of their burdens, and provide most excellent mutton.

Sheep are numerous in India, but they are seldom kept by the cultivator or farmer, for the combination of agricultural with pastoral life, common in other countries, is almost unknown. In the towns of the plains rams are kept as fighting animals, and the sport is a source of gratification to many. A Mohammedan "buck," going out for a stroll with his fighting ram, makes a picture of point-device foppery not easily surpassed by the sporting fancy of the West. The ram is neatly clipped, with a judicious reservation of salient tufts, touched with saffron and mauve dyes, and, besides a necklace of large blue beads, it bears a collar of hawk-bells. Its master wears loosely round his neck or on his shoulders a large handkerchief of the brightest colors procurable; his vest is of scarlet or sky-blue satin, embroidered with color and gold; his slender legs are incased in skin-tight drawers; a gold-embroidered cap is poised on one side of his head; his long black hair, parted in the middle, and shining with scented hair-oil, is sleeked behind his ears, where it has a drake's-tail curl which throws in relief his gold ear-rings; and, in addition to two or three

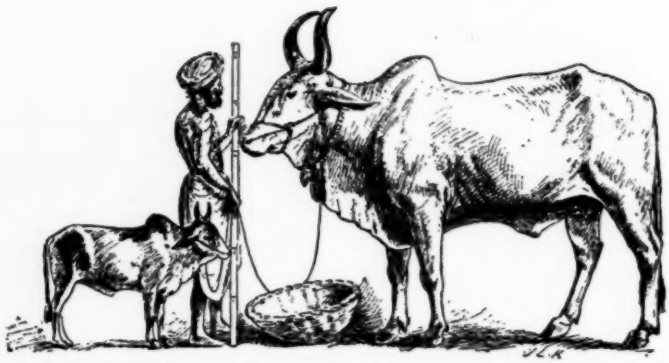

Fig. 4.—Comparative Sizes of the Largest and Smallest Breeds of Indian Oxen.

necklaces, he usually wears a gold chain. Patent-leather shoes and a cane complete the costume. As he first affronts the sunshine, he looks undeniably smart, but his return, I have observed, is not always so triumphant. The ram naturally loses interest in a stroll which has not another ram in perspective, and it is not easy to preserve an air of distinction when angrily propelling homeward a heavy and reluctant sheep.

The beauty of the cow counts almost as much as her usefulness in popular estimation, and the best breeds are really handsome. It is true that a British amateur, accustomed to the level back of the English beast, at first looks unfavorably on the hump and the falling hind quarter. The head seems too large and the body too short. But he acknowledges at once the clean, thoroughbred legs, the fine expression of the eye, the air of breeding in the broad, convex brow and slender muzzle, the character given by the deep, thin dewlap, the smooth, mole-like skin, and in the large breeds an indefinable majesty of mien. In addition to their high caste and shapely look, the hind legs are much straighter and less "cow-hocked" than those of the English animal, and are not swung so far out in trotting. On occasion the animal can jump a fence with a carriage of limbs like that of the horse. So

FIG. 5.—IN A GOOD SEASON.

in a very short time the Briton drops his prejudices, and is even reconciled to the hump, which, like that of the camel and the fat tail of the *dūmba* sheep, has some mysterious relation to the varying conditions of a precarious food-supply. They say vaguely it is a reserve of sustenance, but it would take a physiologist to explain how it acts. Some insist that the sloping quarter is the result of ages of scanty or irregular feeding, but it is now, at all events, a fixed anatomical peculiarity.

To the stranger the great variety of breeds and their adaptation to a wide range of needs and conditions are not at first apparent. He sees an ox and another ox as he sees a native and another native, without noticing that they belong to distinct families. Orientals have a passion for classifying things, and see scores of differences in rice, cotton, wheat, cattle, and horses, which are barely perceptible even to trained English eyes. But among cattle, though there is a bewildering variety of local breeds, some broad differences may be easily learned. The backward slope of the horns of the large and small breeds of Mysore cattle—perhaps the most popular type in use—the royal bearing of the splendid white or fawn oxen of Guzerat, and the transport and artillery cattle bred in the Government farms, at once strike the eye. These are the aristocrats of the race, but they have appetites proportioned to their size, and are too costly for the ordinary culti-

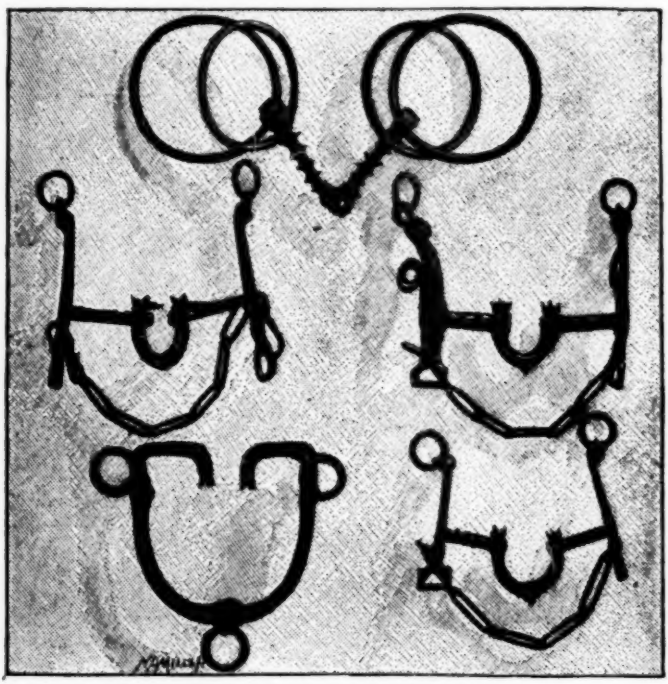

FIG. 6.—INDIAN "THORN-BITS."

vator. They trot in bullock coaches or draw the springless and uncomfortable but delightfully picturesque native *răth* or canopied ox-cart, the wagons of the Government commissariat and of the various Government baggage services.

India has been described by a European as the paradise of horses, and from his point of view the phrase is not unfitting. The natural affinity between horses and Englishmen becomes a

closer bond by residence in India, where everybody rides—or ought to ride—where horses and horse-keep are cheap, and where large castes of stable servants, contented with a low wage, are capable, under careful superintendence, of keeping their animals in a state of luxurious comfort. The horses, however, which serve native masters are born to purgatory rather than to paradise. Those in the hands of the upper classes suffer from antiquated and barbarous systems of treatment, and are often killed by mistaken kindness or crippled by bad training, while those of low degree are liable to cruel ill-usage, overwork, neglect, and unrelieved bondage.

FIG. 7.—A RAJAH'S CHARGER (Marwar Breed).

The "thorn-bits" here engraved are ordinary specimens of those in use; the cut requires careful examination before their murderous character can be made out. Some say the Indian bit is severe because the average horseman, being of slight build, is physically incapable of holding a horse with a fair one. There may be something in this, but the weakness is more moral than physical; nerve is more wanting than muscle, and reason most of all.

When a native chief goes out, he is accompanied by a *sowāri*—literally a "riding" of ministers, servants, guards, and attendants of all sorts. Formerly all rode; but, with good roads, good carriages have been introduced, and usually in these days only the horsemen of the guard ride. But on state occasions, led horses, richly caparisoned, always form part of the show, and there are many animals in princely stables kept solely for processional purposes. The animals most liked are the stallions of Marwar or Kathiawar. White horses with pink points, piebalds, and leopard-spotted beasts are much admired, especially when they have pink Roman noses and light-colored eyes, with an uncanny expression. Their crippled, highly arched necks, curby hocks, rocking gait, and paralytic prancing often proclaim them as triumphs of training.

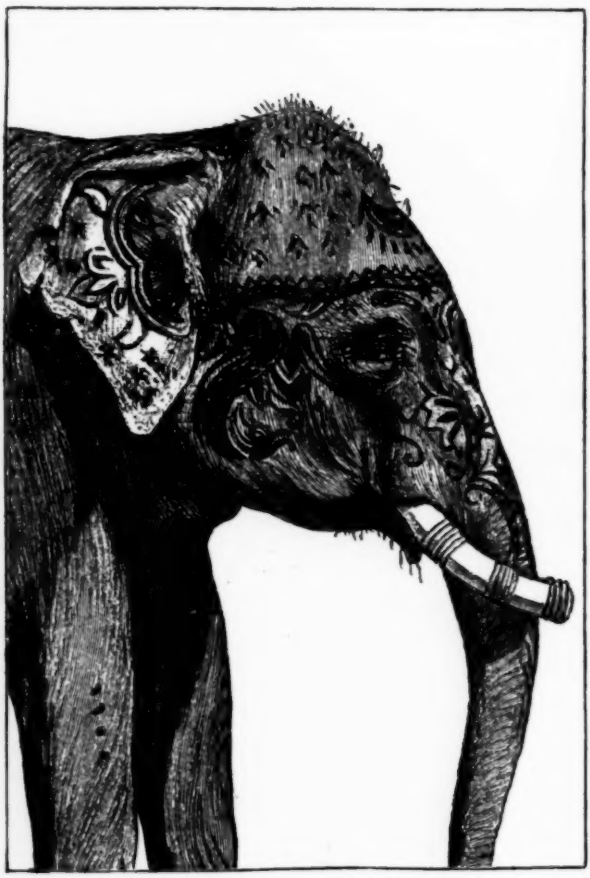

FIG. 8.—A PAINTED ELEPHANT.

The docility of the elephant is never more evident than when he is dressed for parade on an occasion of state. It is a long and tiresome business to clothe the creature in the ornaments and housings with which Oriental taste loves to bedizen him. If the occasion be a very grand one, a day or two will be consumed in preparations. First the forehead, trunk, and ears are painted in bold patterns in color. This is a work of art, for the designs are often good, and the whole *serai*, excepting always the elephant himself, is deeply interested. His mind and trunk wander; he trifles with the color-pots; so with each stroke comes an order to

stand still. Some *mahouts* are quite skillful in this pattern-work. Then the howdah pad is girthed on with cotton ropes, riding over flaps of leather to prevent the chafing to which the sensitive skin is liable. The howdah itself, a cumbrous frame of wood covered with beaten silver plates, is slung and tied with a purchase on the tail-root, and heavy cloths, broidered in raised work of gold and silver thread, are attached, hanging like altar-cloths down the sides. A frontlet of gold and silver diaper, with fringes of fish-shaped ornaments in thin beaten silver, necklaces of large silver hawk-bells and chain-work, with embossed heart-shaped pendants as big as the open hand, and hanging ornaments of chains of silver cartouches, are adjusted. A cresting of silver ornaments, like small vases or fluted soup-tureens, exaggerations of the knobs along a horse's crest, descend from the rear of the howdah to the tail; anklets of silver are sometimes fitted round the huge legs,

FIG. 9.—ELEPHANT LIFTING TEAK LOGS (Burmah).

and a bell is always slung at his side. The pillars of the howdah canopies, and then the canopies themselves, with their finials, are fitted as the beast kneels.

It is officially stated that "all who have had to deal with elephants agree that their good qualities can not be exaggerated; that their vices are few, and only occur in exceptional animals; that they are neither treacherous nor retentive of injury; and that they are obedient, gentle, and patient beyond measure." This is higher and more sympathetic praise than is usually tied up in the pink tape of secretariats, and it is all true.

The normal load for continuous travel of a fair-sized elephant is eight hundred pounds, so the animal is equal to eight ponies,

small mules, or asses; to five stout pack-mules or bullocks, and to three and one third of a camel. Under such a load the elephant travels at a fair speed, keeping well up with an ordinary army or baggage train, requiring no made road, few guards, and occupying less depth in column than other animals. He is invaluable in jungle country and all roadless regions where heavy loads are to be moved. In Burmah, and on the east and southeast frontier, elephants are absolutely necessary for military supply. When once a good road is made the beast is, of course, easily beaten by wheeled carriages.

He shines most as a special Providence when the cattle of a baggage-train or the horses of a battery are stalled in a bog or struggling helplessly at a steep place. An elephant's tusk and trunk serve at once as lever, screw-jack, dog-hooks, and crane, quickly setting overturned carts and gun-carriages right, lifting them by main force or dragging them in narrow, winding defiles, where a long team can not act; while his head, protected by a pad, is a ram of immense force and superior handiness.

A born forester, it is in jungle-work that the laboring elephant, outside Government service, is seen at his best. The tea-planters of Assam and Ceylon find him useful in forest-clearing and as a pack-animal. They even yoke him to the plow. He is the leading hand in the teak trade of Burmah—unrivaled in the heavy toil of the timber-yard, where he piles logs with wonderful neatness and quickness. Small timbers are carried on the tusks, chipped over and held fast by the trunk. A log with a thick butt is seized with judicious appreciation of balance, while long and heavy balks are levered and pushed into place.

The truth about the camel's character has often been debated. He is wonderful, and in his own way beautiful to look at, and his

FIG. 10.—RAJPUT CAMEL-RIDER'S BELT.

patience, strength, speed, and endurance are beyond all praise. The camel-riders of Rajputana and central India, mounted on animals of a swift breed, cover almost incredible distances at high speed, finding it necessary to protect themselves against the rocking motion by broad leather belts, tightly buckled, which are often covered with velvet and prettily broidered in silk. Even they, who know the beast at his best, never pretend to like their

mounts as one likes a horse. So useful a beast is estimable, but the most indulgent observation fails to find a ground for affection. Europeans, at all events, who have to do with camels, seem to think it were as easy to lavish one's love on a luggage-van. He is a morose, discontented, grumbling brute, a servant of man, it is true, as is the water that turns a mill-wheel, the fire that boils a kettle, or the steam that stirs the piston of a cylinder. He does not come to a call like other beasts, but has to be fetched and driven from browsing. There are but few words made for his private ear, such as belong to horses, dogs, and oxen. An elephant has a separate word of command for sitting down with front legs, with hind legs, or with all together, and he moves at a word. A camel has but one, and that must be underlined with a tug at his nose-rope ere he will stoop. But he has a large share in that great public property of curses whose loss would enrich the world.

Camel trappings are not so gaudy in India as in Egypt or Morocco, where riding animals are bedizened in scarlet and yellow. They are in a different key of color, belonging to a school of pastoral ornament in soberly colored wools, beads, and small white shells, which appears to begin (or end) in the Balkans and stretches eastward through central Asia into India, especially among the Biloch and other camel folk on our northwest frontier. Camel housings may be the beginning of the nomad industry of carpet-weaving. It is, perhaps, not too fanciful to trace on the worsted neck-band the original unit or starting-point of the carpets and "saddle-bags" which have given lessons to English upholsterers.

SOCIAL STATISTICS OF CITIES.

LESSONS FROM THE CENSUS. V.

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THE social statistics of our great cities are being put into concrete form by Mr. Harry Tiffany, Chief of the Division of Social Statistics of Cities of the Eleventh Census, under the able direction of Dr. John S. Billings, U. S. Army, expert special agent of the census office. So far the returns on some important leading features comprise about fifty of the principal cities. These facts relate to streets, street-lighting, water-works, sewers, and the police and fire departments. All these, however, are among those features of municipal conditions which are constantly in the minds of men and agitating them as to expenses and the value which they secure in return for taxes paid.

The distribution of population in the fifty cities on which re-

ports have already been published should first be given in any treatment of the social statistics of cities, and the following table answers the purpose admirably well:

Population and Area of Fifty Cities, with Distribution of Population by Square Miles and Acres.

Cities.	Counties.	Population.	Area.		Population to	
			Square miles.	Acres.	Each square mile.	Each acre.
New York....	New York, N. Y.....	1,515,301	40·22	25,740·80	37,675·31	58·87
Chicago.....	Cook, Ill.....	1,099,850	160·57	102,764·80	6,849·66	10·70
Philadelphia..	Philadelphia, Pa.....	1,046,964	129·39	82,809·60	8,091·54	12·64
Brooklyn....	Kings, N. Y.....	806,343	26·46	16,934·40	30,474·04	47·62
St. Louis.....	Missouri.....	451,770	61·35	39,264·00	7,363·81	11·51
Boston.....	Suffolk, Mass.....	448,477	35·28	22,579·20	12,711·93	19·86
Baltimore....	Maryland.....	434,439	28·38	18,163·20	15,307·93	23·92
San Francisco.	San Francisco, Cal...	298,997	15·46	9,894·40	19,340·04	30·22
Cincinnati....	Hamilton, Ohio.....	296,908	25·00	16,000·00	11,876·32	18·56
Cleveland....	Cuyahoga, Ohio.....	261,353	24·88	15,923·20	10,504·54	16·41
Buffalo.....	Erie, N. Y.....	255,664	39·04	24,985·60	6,548·77	10·23
New Orleans..	Orleans, La.....	242,039	37·09	23,737·60	6,525·72	10·20
Detroit.....	Wayne, Mich.....	205,876	20·59	13,177·60	9,998·83	15·62
Milwaukee...	Milwaukee, Wis.....	204,468	17·00	10,880·00	12,027·53	18·79
Washington..	District of Columbia..	202,978	10·24	6,553·60	19,822·07	30·97
Newark.....	Essex, N. J.....	181,830	17·77	11,372·80	10,232·41	15·99
Minneapolis..	Hennepin, Minn.....	164,738	51·67	33,068·80	3,188·27	4·98
Omaha.....	Douglas, Neb.....	140,452	24·50	15,680·00	5,732·73	8·96
Rochester....	Monroe, N. Y.....	133,896	15·60	9,984·00	8,583·08	13·41
St. Paul.....	Ramsey, Minn.....	133,156	51·42	32,908·80	2,589·58	4·05
Denver.....	Arapahoe, Col.....	106,713	15·49	9,913·60	6,889·15	10·76
Indianapolis..	Marion, Ind.....	105,436	10·07	6,444·80	10,470·31	16·36
Worcester....	Worcester, Mass.....	84,655	34·02	21,772·80	2,488·39	3·89
Toledo.....	Lucas, Ohio.....	81,434	19·72	12,620·80	4,129·51	6·45
New Haven..	New Haven, Conn....	81,298	7·56	4,838·40	10,753·70	16·80
Lowell.....	Middlesex, Mass.....	77,696	11·15	7,136·00	6,968·25	10·89
Nashville....	Davidson, Tenn.....	76,168	8·44	5,401·60	9,024·64	14·10
Fall River....	Bristol, Mass.....	74,398	10·95	7,008·00	6,794·34	10·62
Cambridge...	Middlesex, Mass.....	70,028	5·83	3,731·20	12,011·66	18·77
Camden.....	Camden, N. J.....	58,313	4·34	2,777·60	13,436·18	20·99
Trenton.....	Mercer, N. J.....	57,458	3·95	2,528·00	14,546·33	22·73
Lynn.....	Essex, Mass.....	55,727	10·64	6,809·60	5,237·50	8·18
Hartford.....	Hartford, Conn.....	53,230	14·66	9,382·40	3,630·97	5·67
Evansville....	Vanderburg, Ind....	50,756	4·42	2,828·80	11,483·26	17·94
Los Angeles..	Los Angeles, Cal....	50,395	27·60	17,664·00	1,825·91	2·85
Lawrence....	Essex, Mass.....	44,654	6·67	4,268·80	6,694·75	10·46
Hoboken.....	Hudson, N. J.....	43,648	1·47	940·80	29,692·52	46·39
Dallas.....	Dallas, Texas.....	38,067	7·68	4,915·20	4,956·64	7·74
Sioux City....	Woodbury, Iowa.....	37,806	30·90	19,776·00	1,223·50	1·91
Portland.....	Cumberland, Me.....	36,425	2·51	1,606·40	14,511·95	22·67
Holyoke.....	Hampden, Mass.....	35,637	3·98	2,547·20	8,954·02	13·99
Binghamton..	Broome, N. Y.....	35,005	10·04	6,425·60	3,486·55	5·45
Duluth.....	St. Louis, Minn.....	33,115	3·23	2,067·20	10,252·32	16·02
Elmira.....	Chemung, N. Y.....	29,708	4·45	2,848·00	6,675·96	10·43
Davenport...	Scott, Iowa.....	26,872	4·41	2,822·40	6,093·42	9·52
Canton.....	Stark, Ohio.....	26,189	6·80	4,352·00	3,851·32	6·02
Taunton.....	Bristol, Mass.....	25,448	47·40	30,336·00	536·88	0·84
La Crosse....	La Crosse, Wis.....	25,090	8·19	5,241·60	3,063·49	4·79
Newport.....	Campbell, Ky.....	24,918	1·20	768·00	20,765·00	32·45
Rockford....	Winnebago, Ill.....	23,584	6·37	4,076·80	3,702·35	5·78

The total population of the cities comprehended in the foregoing table is 10,095,370. The areas have been determined by actual

measurements, and from latest obtainable data, or from records in the offices of the city engineers of the respective cities. Fall River is an exception to this rule, as the boundaries of Wards 6 and 9 in that city have never been accurately defined. The city of Washington, in the table, includes the area and population inclosed within the actual municipal boundaries, and not the total area and population of the District of Columbia. The islands in the East River, with an area of five hundred and twenty acres, and which are geographically situated in Wards 12, 19, and 23, are included as part of New York.

The most interesting feature of the foregoing table is that relating to the distribution of population according to area; but in this one must not be deceived. The population to each acre or to each square mile of a city can not well be compared with like data for another city, unless the exact area of dense population is known—as, for instance, a city may comprise fifty square miles of territory and have 500,000 population, which would give a population of 10,000 to each square mile, but the population may be compressed into twenty-five square miles, when the actual distribution would be 20,000 persons to the square mile; while another city of like area and like total population, but with the population distributed more evenly over the whole area, would be in a much better sanitary condition than the first city named, although in statistics the population per square mile would be the same when the whole area is considered.

Twenty-two of the cities named in the foregoing table have a population of over 100,000 each, the total being 8,737,648, which is 13·95 per cent of the total population of the country. The population to the square mile of these twenty-two cities is 15·92 to the acre; but the differences in ratios of population to area are very great, ranging from four in St. Paul, five in Minneapolis, nine in Omaha, ten in New Orleans and Buffalo, eleven in Chicago and Denver, and twelve in St. Louis, to thirty in San Francisco, thirty-one in Washington, forty-eight in Brooklyn, and fifty-nine in New York. These figures represent population to a square acre. So skillful a statistician as Dr. Billings is of course careful to remark that the ratios indicated by the statistics published "give no information as to the difference in density of the population in the actually built-up portions," and he cites that in New York the number of persons per acre ranges from four hundred and seventy-four in Ward 10 to three in Ward 24, while in Chicago there is a range from one hundred and sixteen in Ward 16 to two in Wards 28 and 23. These instances show the extremes, and teach us emphatically that any comparison of population to the square acre or to the square mile for the purpose of drawing conclusions relative to sanitary and other conditions must be

avoided. Physicians have taken considerable interest in censuses, and for the very reasons stated, and so in many cases health districts have been prescribed and the statistics of population and the social facts relating to population for such health districts preserved. In this way the very best results are to be reached. With complete statistics of population for clearly defined health districts, where the sanitary conditions can be compared and differences of conditions noted, a scientific study of death-rates with reference to the density of population can be undertaken. The ordinary statistics of death-rates based on the density of population of cities are exceedingly vicious, but perhaps not more so than the ordinary statements relative to the death-rate of cities based on the whole population. There is great liability to very misleading statistics in this direction. The errors arise from two causes. The first of these is the incompleteness of death statistics. This can only be overcome by a compulsory registration of deaths. The second cause is that population is not accurately known except for periods some distance apart, and here error arises, and would arise, even with complete and perfect statistics of deaths; as, for instance, a State which depends entirely upon the Federal census ascertains its population only once in ten years. For the census year the death-rate based on population may be fairly accurate; but for intermediate years the death-rate must be based upon calculations of population mathematically made. In some cases this has led to very vicious results, and has caused considerable fright and anxiety on account of the great apparent death-rate, when, had the facts all been known, it would have been found that the death-rate was really normal. Another feature of error, or rather feature for the basis of erroneous conclusions, relative to the death-rate in great cities, arises from the fact of the existence of large hospitals in cities, and that the death-rate is increased by people coming from the country to the cities for treatment and there passing away, thus giving an abnormally high death-rate relative to the actual living population of a city. This is also true in connection with the criminal statistics of cities. Men come in from country towns for the purpose of a visit or a spree, or for carrying out some nefarious design. At all events, they commit crime, from one cause or another, within the city limits, are there arrested and punished, and their crimes help to swell abnormally the legitimate criminal statistics of the city itself. All these considerations should be taken into account when writers are undertaking to draw what they feel to be accurate conclusions through comparisons of statistics. I have read very learned essays upon conditions of the population, involving insanity, crime, disease, death, etc., when all the conclusions of the essays were based upon most incomplete

and unsatisfactory data—in fact, upon statistics that were not within a large percentage of accuracy. When treating the vital statistics of the whole country I shall take pains to call attention to some of the exceedingly misleading if not thoroughly erroneous conclusions in the past. It is exceedingly gratifying to know that the experts in charge of such important facts under the eleventh census are thoroughly alive to all the opportunities of error which ordinarily and naturally arise under imperfect statistics.

The discussions which are going on relative to municipal control will be enriched by a great many facts in the social statistics of cities that are being published under the eleventh census. The difference in the cost of building and maintaining streets and in the cost of street-cleaning, the advantages of paved or unpaved streets so far as health is concerned, and the general conditions resulting from cleanliness—all these facts can be learned when the complete statistics of cities are published. Boston, Worcester, and Holyoke are cities in which all the streets are paved; but Dallas, Texas, has but 4·7 per cent of its streets paved, St. Paul 4·1, and Minneapolis 3·1, while Denver's streets are not paved at all.

The average yearly cost of construction and repairs per head of population in cities having over 100,000 inhabitants is $1.54, while in twenty-seven cities for which the census has returns, having less than 100,000 inhabitants each, the cost is $2.04.

The average annual expenditure for street-cleaning varies from five cents in Buffalo and eight cents in Chicago to seventy-one cents in New York and sixty-two cents in Cincinnati; but, as the census officials remark, there is probably no definite relation between the cost per head of street-cleaning as shown by the figures and the actual condition of the streets as to cleanliness. Ordinary observation teaches us that in many cities where the cost is greatest the streets are in the filthiest condition.

The question as to economical street-lighting is an important one in all municipalities. The facts already published indicate that the annual cost of gas-lamps varies from $50 per lamp in New Orleans, $43.80 in San Francisco, and $37 in St. Louis, to $15 in Indianapolis and Canton, $15.60 in Minneapolis, and $17.50 in Hoboken; while the annual cost of each electric lamp varies from $68 in Chicago and $58.46 in Denver to $237.25 in Boston and $440.67 in San Francisco. When all the facts are collected and published it is to be hoped that the public can ascertain the relative advantages of the different systems of lighting, so far as cost per capita is concerned. At present the cost to each head of population can only be stated for the total average annual cost for the cities comprehended in the table. This is sixty-four cents

per annum. Not only will the facts be shown relative to the cost per capita of each method of lighting the streets of a city, whether by gas, electric light, or oil, etc., but the relative advantages of lighting streets by works owned by the city and works owned by private corporations will be shown. It is a fact that the gas-light is gradually giving place to the electric light; for, while the facts for the cities named in the tables already published by the census office show that gas-lamps comprise over sixty per cent of all classes used for street-lighting, it is evident that they are now rarely used exclusively for lighting. It is also learned that electric lighting is most favored in those cities that have less than 100,000 inhabitants each; for, in 278 such cities, out of a total of 91,667 lamps, 35,127 are gas-lamps, 35,191 are electric lamps, and 21,149 are lamps burning oil, etc. Taking the total cities from which reports have been received relative to light, being 309 cities, with a population of 16,335,569, the total number of lamps of all kinds is 293,847, the gas-lamps numbering 182,671, the electric lamps 53,696, and the oil-lamps 57,480.

The interest which now centers in the question as to whether *quasi* public works shall be controlled by private corporations or by the municipality itself is illustrated more specifically by the facts connected with water-works than by those surrounding any other character of city works, and the difference as to cost of maintenance and receipts between public and private works is very noteworthy. The facts are already given quite fully by the census for fifty cities, and of these thirty-five own their own water-works. The average cost of construction in the thirty-five cities owning their own water-works to each head of population is $21.35, while in thirteen cities where the water-works are owned by private parties the cost of construction to each head of population is $31.20, or nearly ten dollars more per capita than where the cities construct their own works. Out of 273 cities reporting to the census on their water-works, fifty-six per cent own and operate their own works, the remainder depending on private companies for their water-supply; but the fifty-six per cent represent seventy-seven per cent of the total population of the 273 cities. A greater proportion of private works perhaps are to be found in the smaller cities; for, out of 133 such cities, having a population of 3,708,994, 112 cities, representing 2,351,574 people, have their water-works operated by private parties.

The sewers of the cities of the country are under the control and direction of the municipal governments. The construction has been under public control. In Baltimore, where the sewers are intended for the removal of storm water only, is found the smallest percentage of sewers to streets in the larger cities, it being only 3·56. The cities of Washington and Cambridge have

more miles of sewers than of streets. In 190 cities the population to each mile of sewer is 1,815.

The social statistics of cities already published comprehend tables on the points which have been discussed; and, further, as stated, on the police and fire departments. In the latter two sections the chief interest relates to the cost of each force. Selecting some of the salient features relative to the police, it is interesting to learn that in New York there are 72·65 patrolmen to each square mile of territory, while in Chicago there are but 9·08, in Philadelphia 11·01, in Brooklyn 34·01, in St. Louis 8·72, in Boston 19·25, in Baltimore 21·81, in San Francisco 21·73, in Cincinnati 16, in Cleveland 10·13, in New Orleans 4·66, and in Washington 35·64.

The criminal conditions as indicated by arrests, if arrests be a fair indication, are shown by the following facts: In New York the number of arrests to each patrolman is 25·53, in Chicago 27·37, in Philadelphia 35·09, in Brooklyn 31·52, in St. Louis 32·98, in Boston 48·41, in Baltimore 42·96, in San Francisco 69·68, in Cincinnati 35, in Cleveland 29·76, in Buffalo 41, in New Orleans 86·71, and in Washington 48·71.

The question as to what a man receives for the taxes he is called upon to pay is not only an exceedingly interesting one from an economic point of view, but of real, vital consequence to the welfare of the people. I have therefore constructed an entirely new table from the various tables already reported by the census, showing the average cost per head of population in the fifty cities named for the construction and repairs of streets, for street-cleaning, for lamps of all kinds, for the maintenance and repairs of sewers, for the police force, for the fire department, and for water, with a total which all these items of expenditure make for each inhabitant in the fifty cities named. (See table on following page.)

The averages in the tables from which the foregoing is drawn are, as I understand it, for the ten years ending January 1, 1890, except in some cases where municipal governments have been of recent growth, in which cases the averages are for the years during which the work has been carried on. It is evident, however, that the averages have been very carefully worked out, and represent more forcibly than any statements heretofore published the cost in the great branches of city government in the cities named. I hope in some future paper to add the cost of the educational work of the cities, and some other features, so as to show the exact expenditures which one has to make for the maintenance of the various branches of city affairs. It must be remembered that the average cost per head of population, as shown in the last table, represents the cost to each man, woman, and child. It must also be remembered that the cost is not paid directly, in accord-

Cities.	Average Cost per Head of Population in Fifty Cities.							
	For construction and repairs of streets.	For street cleaning.	For all lamps.	For maintenance and repairs of sewers.	For police.	For fire department.	For water.	Total.
New York, N. Y....	$0.68	$0.71	$0.43	$0·077	$2.90	$1.06	$1.20	$7.057
Chicago, Ill.....	3.18	0.08	0.58	0.075	0.89	0.64	2.80	8.245
Philadelphia, Pa....	0.61	0.27	0.70	0.024	0.96	0.60	1.80	4.964
Brooklyn, N. Y.....	0.49	0.20	0.59	0.066	1.07	0.70	1.60	4.716
St. Louis, Mo.....	1.85	0.28	0.43	0.057	1.05	0.62	2.80	7.087
Boston, Mass.....	1.84	0.30	1.24	0.263	2.15	1.78	2.40	9.973
Baltimore, Md.....	0.28	0.25	0.70	0.023	1.56	0.35	1.40	4.563
San Francisco, Cal...	3.21	0.20	0.94	0.094	1.82	1.15	4.00	11.414
Cincinnati, Ohio.....	2.88	0.62	0.73	0.084	1.11	0.92	2.50	8.844
Cleveland, Ohio.....	1.34	0.19	0.61	0.023	0.96	0.77	2.25	6.143
Buffalo, N. Y.....	2.24	0.05	0.11	0.017	1.17	0.88	2.40	6.867
New Orleans, La....	0.14	0.10	0.71	.....	0.70	0.66	5.00	7.310
Detroit, Mich.....	1.63	0.16	0.56	0.062	1.08	1.03	2.00	6.522
Milwaukee, Wis.....	2.29	....	0.59	0.095	0.60	0.82	2.20	6.595
Washington, D. C...	2.50	0.31	0.77	0.119	1.97	0.49	0.90	7.059
Newark, N. J.....	0.11	0.16	0.67	.....	0.93	0.49	2.75	5.110
Minneapolis, Minn...	1.21	....	1.01	0.006	0.92	0.76	1.80	5.706
Omaha, Neb.....	4.15	0.16	0.26	0.032	0.46	0.46	2.40	7.922
Rochester, N. Y.....	1.06	0.15	1.06	0.015	0.74	0.45	1.40	4.875
St. Paul, Minn.....	5.69	0.28	1.06	.....	0.74	1.01	1.72	10.500
Denver, Col.....	0.45	....	0.95	0.023	0.47	0.94	3.40	6.233
Indianapolis, Ind....	2.61	0.47	0.44	.....	0.53	0.71	2.40	7.160
Worcester, Mass....	1.65	0.08	0.94	0.112	0.87	0 59	3.00	7.242
Toledo, Ohio	4.03	0.10	0.66	.....	0.90	0.76	2.20	8.650
New Haven, Conn...	1.68	0.06	0.79	0.001	1.26	0.92	2.40	7.111
Lowell, Mass.....	1.27	....	0.73	0.167	0.91	0.91	2.60	6.587
Nashville, Tenn.....	1.71	....	0.38	0.001	0.60	0.73	4.40	7.821
Fall River, Mass....	0.89	....	0.37	.....	0.95	0.57	3.00	5.780
Cambridge, Mass....	0 64	0.36	0.69	0.174	1.02	0.85	3.40	7.034
Camden, N. J.....	0.38	0.19	0.59	0.010	0.51	0.34	2.20	4.220
Trenton, N. J.....	0.17	0.03	0.70	.....	0.96	0.38	2.00	4.240
Lynn, Mass.....	0.72	0.18	0.66	0.045	0.72	0.85	2.20	5.375
Hartford, Conn.....	0.88	0.11	0.86	0.025	1.03	1.11	1.80	5.815
Evansville, Ind.....	0.66	0.15	0.64	0.030	0.55	0.79	3.00	5.820
Los Angeles, Cal....	....	....	1.15	.....	0.57	1.33	4.80	7.850
Lawrence, Mass.....	0.74	0.07	0.34	.....	0.73	0.49	2.40	4.770
Hoboken, N. J.....	0.46	0.05	0.44	0.046	0.96	0.23	2.35	4.536
Dallas, Texas.....	0.47	....	0.50	0.394	1.05	0.92	6.20	9.534
Sioux City, Iowa....	20.05	0.18	0.40	0.053	0.32	0.53	2.40	23.913
Portland, Maine.....	1.59	....	0.84	0.049	0.93	0.40	4.60	8.409
Holyoke, Mass.....	0.51	....	0.61	0.561	0.56	1.13	2.20	5.571
Binghamton, N. Y...	0.43	0.03	0.63	.....	0.24	0.43	3.00	4.760
Duluth, Minn.....	15.00	0.15	0.68	0.138	1.21	1.51	4.00	22.688
Elmira, N. Y.....	0.40	0.07	0.80	0.017	0.60	0.74	3.60	6.227
Davenport, Iowa....	1.12	0.19	0.61	0.004	0.44	0.52	1.60	4.484
Canton, Ohio.....	1.22	....	0.69	.....	0.32	0.45	1 60	4.280
Taunton, Mass.....	1.41	....	0.61	.....	0.74	0.51	2.60	5.870
La Crosse, Wis.....	0.81	....	0.51	.....	0.40	0.37	2.40	4.490
Newport, Ky.....	0.60	0.16	0.37	.....	0.40	0.32	3.40	5.250
Rockford, Ill.....	0.51	0.08	0.51	0.013	0.32	0.51	2.20	4.143

ance with the items specified, but that to the whole city the cost per capita is as stated. According to all economists, however—and there is no reason to take issue with the proposition—the taxed cost is borne by every man, woman, and child, either directly or indirectly. It is fair, therefore, to assume that in each of the cities named, for each person there must be paid, either

directly, by an assessed tax, or indirectly, through the increased cost of articles of consumption, of rent, etc., the cost specified.

The column for water is not particularly satisfactory, although it is indicative of the actual expense. The census tables show only expense of annual charge for water for an average dwelling, meaning by an average dwelling one that is occupied by one family and not exceeding seven rooms, with one bath-room, including hot and cold water, and one water-closet. If an average dwelling is one occupied by one family, then one fifth of the annual charge for water as given in the census reports would show with reasonable accuracy the charge for each individual, and on this basis the column for water has been constructed.

Looking at the items for each of the fifty cities named in the last table and the total, we easily ascertain what a man receives for the tax which he is obliged to pay directly or indirectly, and also in which city he receives the most for his money, or, rather, where he receives all his protection of police, his use of streets, his protection from fire, etc., for the least expenditure, and the analysis also leaves in each man's mind this question: Could he secure so great a return for his money by any other method of expenditure?

There are a few blanks in the table just given; as, for instance, in New Orleans the expense for the maintenance and repairs of sewers is missing, and this item is also omitted from the reports for Newark, St. Paul, Indianapolis, Toledo, Fall River, Trenton, Los Angeles, Lawrence, Mass., Binghamton, Canton, Taunton, La Crosse, Wis., and Newport, Ky. There are also a few other points missing; as, for instance, the expense of street-cleaning in Milwaukee, Minneapolis, Denver, and some other cities. These points, however, comprehend nearly all the omissions, and in so far as they occur the total expense in the cities named is vitiated, although to a very small extent.

Taking the table as it stands, it is seen that Rockford, Ill., offers the most for one's taxes of the smaller cities, it being $4.14 per capita. Camden, N. J., comes next, with $4.22; and Trenton follows, with $4.24. Among the larger cities, those having over 200,000 inhabitants, Baltimore offers the very lowest expense for her great departments of government, the per capita expense for all being $4.66. Brooklyn, N. Y., comes very close, the expense being $4.71, and Philadelphia ranks third as to cheapness of municipal government for the items named, the expense being $4.96. The great city of New York, about which so much is said relative to her expensive government, furnishes the seven items of expense named in the table at $7.05 per capita, being lower than St. Louis, Chicago, Boston, San Francisco, Cincinnati, or New Orleans, and ranking almost exactly with Washington. The most expensive

city on the list is Sioux City, Iowa, and the next is Duluth, Minn., the expense being in the first $23.91 and in the second $22.68; but this great expense is probably due to the extensive construction of streets in a recent period, and therefore the expense of these two cities should not be compared with that of others. Throwing out the cities with abnormal conditions, it is probable that San Francisco is the highest cost city in the list of fifty given in the table, the expense being $11.41 per capita.

The table will be found interesting in many respects, as comparisons can easily be made for one city with another, not only as to total per capita cost, but as to the items enumerated. Looking at the city of New York, for instance, the table means that it would cost a family of five $35.25 per annum for the benefits accruing to it from the use of streets and the cleaning thereof, for public lighting, for the maintenance and repairs of sewers, for police protection, for the protection of the fire department, and for the use of water. No one can object to an expense for a family of five persons no higher than that named for all these great advantages. The working-man with five in his family is not taxed this $35.25 directly, as intimated, but he has to pay it in rent and the cost of his living. Is it an unreasonable addition to his annual expenses? is the question. It does not matter whether the total expense is high or low for all the advantages detailed; the great question is, Could they be furnished as efficiently and as well in every respect for a less sum, with the integrity of all departments preserved? If they could, then a man is entitled to the less expense. If not, he should certainly be entirely satisfied with the great return which he now gets for the money expended.

WAYSIDE OPTICS.

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OUR train has been traveling for the past twenty-four hours over that part of a transatlantic route which stretches from the Sierra Madre to the extreme borders of the great Mohave Desert. There are many interesting things to be seen along this line of travel, but nothing more striking than the curious optical phenomena presented by the pleasing alternation of vast plain with rugged mountain. For example, not far from the last station we come upon a lofty peak overtopping the surrounding hills. It seemed to be about ten miles away, but was in reality fifty.

As is well known to the student of optics, the apparent size of an object is mainly dependent upon the size of the image which

it makes upon the retina, just as its apparent distance from the observer is determined chiefly by the distinctness of the impression formed upon the background of the eye. The rays of light reflected from the distant mountain made a distinct image upon my retinæ because they traversed a rarefied atmosphere of uniform density which produced the minimum amount of refraction, dispersion, and absorption. Previous to this time I had been accustomed, under Eastern skies, to view distant objects through media neither so rare nor so uniform as this mountain air, and it was not, therefore, strange that my calculations of distance should in this case be erroneous. Such phenomena, familiar enough to most travelers and to every dweller in the "cool, thin atmosphere" of mountainous regions, are almost startling when seen for the first time. It is difficult to believe that the huge, stony mass, apparently so near—certainly so plainly seen—is over half a hundred miles away.

The illusion as to distance does not, however, extend to the matter of size. Mountains and hills may, under certain atmospheric conditions, appear to be near at hand when they are actually far away, but their apparent size remains always the same. The same mountain would appear of just the same size in Colorado as in Vermont. We know this because objects equally distant and of the same size always subtend the same visual angle. The greater the distance from the eye, the smaller the visual angle and retinal image; the less the distance, the greater the angle and the larger the image—as the following diagram (Fig. 1) shows:

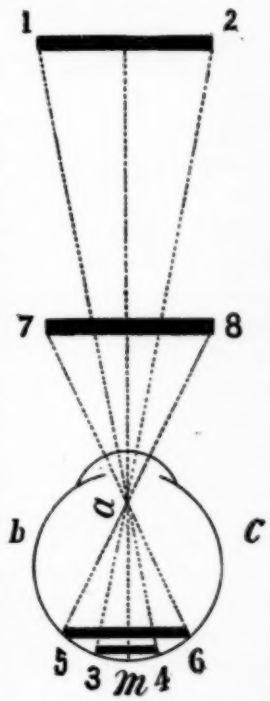

FIG. 1.

The rays of light falling through the pupil upon the retina, *b m c*, cross at the nodal point *a*. The near object, 7 8, subtends a larger visual angle, 7 *a* 8, and makes a larger retinal image, 5 6, than the distant object, 1 2.

It would be interesting to test the truth of these statements by actual experiment, if ideas of size and distance did not, unfortunately, vary with the individual, and were not subject to almost daily modification by experience and other influences. Calculations as to the actual size and distance of the most familiar objects are, within certain limits, but pure guesses on the part of the great majority of people; so that, even if it were worth the while, the most of us could never become experienced enough,

by making a study of distant objects, to do more than roughly approximate their actual size and distance away.

In making estimates of this kind we are, in the latter instance, very materially assisted by the peculiar "distance tints" which the mountains assume. The brain becomes accustomed, after a large number of experiences, to associate a certain coloration of objects with certain distances from the eye, and in this way to calculate the distance of an object seen for the first time. Einthoven thinks that the chromatic aberration which even a normal eye exhibits may account for the peculiar colored appearances which distant objects take on.

This explanation is manifestly opposed to the view commonly held, that the minute globules of water in the air act as prisms, and, resolving white light into its component colors, robe the distant mountains in "azure hues." In either case the peaks of the Sierras would deceive the unfamiliar eye, for not only are they more distinctly seen than their fellows of the Atlantic States, but their "distance tints" would entirely mislead the unaccustomed observer.

As the train proceeds rapidly over the level desert my eyes "fix"*—i. e., gaze steadily at—a clump of sage-bush which is probably two miles distant. The bush seems to move slowly *with* the train, while objects between it and my eyes have an apparent motion in the opposite direction. Of these latter the near ones fly past with great rapidity, but the apparent velocity of those farther removed diminishes until, just before the point of fixation is reached, objects come to an apparent standstill. Beyond the point fixed by my eyes objects move in the same direction as the train, their velocity apparently greater the farther away they lie.

Suddenly I shift my gaze from the sage-bush to a large bowlder which is sailing slowly past, probably one thousand yards from the train. Everything is changed at once. The bowlder's retrograde progress is arrested; near objects fly past with accelerated speed; the sage-bush clump forges ahead as if to make up for lost time, while the plain beyond it, indistinct in the distance, races ahead of every object in view. And so I while away a full half-hour, making one conspicuous object after another stand still, go ahead, or sail past at will—all upon the surface of this apparently boundless plain—trying to realize, meantime, that things are *not* as the moving panorama before me indicates. For, relatively to the train, all objects are passed at an equal rate, the near as well as the distant, those seen by direct as well as those seen

* When the eye fixes anything, the visual apparatus is so adjusted that the rays of light coming from the object are focused upon the *macula*, a small central spot in the retina, where vision is most acute; and the object thus fixed is seen more distinctly than surrounding bodies.

by indirect vision. But, in looking from my car window, I am made the subject of optical illusions common in a journey of this sort.

Notwithstanding the many wonderful things about the mechanism of vision, it exhibits, after all, a great many crudities. Intellectually, for instance, the optic centers are low down in the scale of origin. Even the olfactory nerves have a higher cerebral origin than they. Accordingly, we often find them committing all sorts of errors, from whose consequences only the experience of the other organs (acting as special detectives) enables the organism to escape.

Simple "seeing" ought not to be followed, in all cases, by implicit belief. When, for example, as in this case, the eye forms part of a moving mass, the motion is wrongly attributed by the optic centers to surrounding bodies. The explanation of how this comes about is easy when one considers certain facts in elementary optics. If I close one eye and slowly move a pen from right

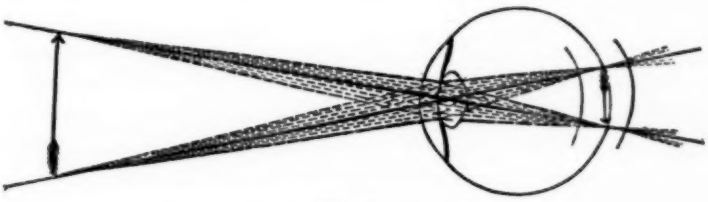

FIG. 2.

to left a few inches in front of the other eye, the direction of the movement is rightly interpreted by my brain, although by a reference to Fig. 2 it will readily be seen that the retinal image of the pen moves in an opposite direction over the background of the eye.

Precisely the same effect is obtained if, instead of moving the pen, I look straight forward and move my head from left to right, simply because the same impression is produced—i. e., the retinal image moves from left to right.

When, therefore, the image of an object is made, it matters not *how*, to move over the retinal background, motion in an opposite direction is immediately referred to the object itself. It makes no difference, then, so far as the optical effect is concerned, whether the solid plain with the objects on its surface be carried past the observer at rest, or whether the observer himself move past or over the plain. Further, when there is no movement of the image over the retina, no motion is detected by the eye; optically, the object is at a standstill. That a body moving in front of the eye should appear to be stationary, its image must always be kept in the same position on the retina. This is accomplished

by the alert ocular muscles. When, however, the object is too near the eye, or when its motion is too swift, the muscles are not quick enough in their action to preserve this delicate state of optical rest; the image is thrown across the retina, and the object is seen to move. A glance at this diagram (Fig. 3) will show how these retinal impressions are received and interpreted.

The first figure is intended to represent three objects seen from a train in motion. Although the middle one is fixed by the eye, and is consequently most distinctly seen, the blurred images of the other two also fall upon the macula, so that for a single instant they are all optically at rest. A moment later, the eye, still fixing the middle object, has moved from 1 to 2, and, as is seen in 2, the images corresponding to the near and the remote objects have passed over the retinal area. Motion in the opposite direction is, according to the law just laid down, attributed to each, while the middle object still gives the impression of comparative rest.

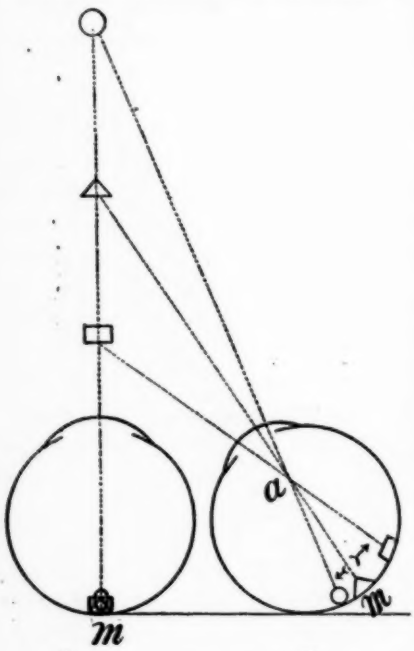

FIG. 3.

When, however, the image of the moving object is kept fixed upon the macular region, the eye may judge of the rate of its motion by *the amount of effort* put forth by the ocular muscles necessary to keep the image focused upon the macula.

This method of calculation is defective, and gives rise to numerous optical errors. For example, the movement of a lady's fan in front of her face, the velocity of a base-ball through the air five hundred yards off, and the rate at which the night express travels as it approaches "end on"—its head-light gleaming in the distance—would all be incorrectly calculated if the brain were to accept ocular evidence alone and based on one or both of the foregoing rules. The to-and-fro movement of the fan would be interpreted as exceedingly quick; the velocity of the base-ball would be next in order; while little or no motion would be attributed to the approaching train.

Becoming tired of looking at the wayside scenery, I find myself, in a sort of brown study, watching the back of the plush-covered seat in front of me, and then I discover that the retinal

impressions made by the moving pageantry of the Arizona desert are curiously transferred to this crimson background. For I see a strip of plush moving irregularly to the right of me, and just above it another section moving to the left.

As the movements of the plush correspond very nearly to the previous visual impressions made by the moving landscape, I soon find that I can vary the plush movements at will.

Allowing sufficient intervals of rest to elapse, I am able to make an upper segment of the plush cushion move slowly backward or forward in contrast with a lower portion—a faithful photograph from the landscape negative.

This persistence of strong or continued retinal impressions may easily be demonstrated by another and commoner experiment. Look intently for two or three minutes at the light falling through a small window, other illumination being excluded. Then close the eyes and place a bandage over them. The impression produced by the light persists several minutes, and the experiment will be all the more striking if the window be crossed by bars, the persistent images of which are seen distinctly in strong contrast to the lighted spaces surrounding them.

Kühne, of Heidelberg, and others have shown that the retina possesses a pigmentary substance (visual purple), sensitive to light, which acts like the sensitized plate or film of the photographic camera, and that a picture distinctly seen is actually photographed upon the background of the eye.

Looking from the rear platform of our vestibule train—an admirable vantage-ground from which to view the country through which one is passing—I find that we have just skirted some foot-hills and are approaching the mouth of a small cañon, at the head of which a bold, black mountain looks threateningly down on the desert below. The train once more gains the level country, and on looking back, although it is far up the gorge, the mountain seems very near. Nay, more, as I look first at the roadbed and then at the base of the huge mass in front of me, the latter, in some uncanny way, follows, as if it wished to fall upon and crush me. This apparent motion reminds me of Shelley's description:

> "The Apennine in the light of day
> Is a mighty mountain dim and gray,
> Which between the earth and sky doth lay;
> But when night comes, a chaos dread
> On the dim starlight then is spread,
> And the Apennine walks abroad with the storm."

Not so, however, is it with this particular outpost of the Sierra Madre. The fact is that while I have, at the car window, been experiencing the retinal effects produced by objects moving in a

direction apparently parallel to the horizon, I am now having an object-lesson in optics with bodies whose apparent motion is at an angle to the horizontal line. In both these cases the explanation of the observed phenomena is precisely the same. The body of the mountain represents the most distant objects on the level desert, its base is the point of fixation, while the near objects are between it and the receding train.

The rails, sleepers, and the gravel fly past with a velocity which apparently diminishes in the distance; the mountain-base is practically at a standstill, but beyond it is the prominent bulk of the mountain itself, which appears to advance in obedience to the laws we have just been considering.

But my cerebral convolutions refuse to accept such evidence. They insist, these maturer products of the evolutionary force, that the organism has never had any experience of mountains chasing railway trains. And so it happens that I, placing my trust in an enlightened experience rather than in a report from my childish optical centers, feel assured that this particular mountain is *not* following us.

The prevailing idea that the organ of vision is practically a perfect piece of optical and nervous mechanism has done not a little to discourage attempts to develop those wonderful powers which it undoubtedly possesses.

One may, by judicious education, train and improve an undeveloped sense, but what improvement can be wrought in a perfected organism?

Far too little has been done in this direction, not only among children during school life, but in after-years spent at literary, technical, or other institutions. Of course, it may be asserted that the sense of sight, in conjunction with the other senses, receives its due share of developmental training in the ordinary course of general and special instruction. But, as opposed to this, may be urged, in the first place, the *natural deficiencies* of the eye, a few of which have just been referred to; and, in the second instance, the splendid results which, despite these innate defects, are obtainable by judicious training—results richer far than any other sense is capable of attaining.

This plea for a systematic exercise of the visual functions does not exclude the payment of proper attention to the other senses. It is asserted merely that our knowledge would be more complete if a larger proportion of the time and attention given to the cultivation of the special senses were devoted to the development of the capable but congenitally deficient organ of vision.

As a preliminary to this there should never be forgotten the *care of sight.* A great deal has been said (and too much, perhaps, can not be said) about the importance of ocular hygiene, especial-

ly as applied to schools and school children; but, in addition to these sanitary measures as applied to the mass, inspection of *individual* cases should be insisted upon. How many useful eyes might have been saved to the commonwealth if they had been examined and treated early in life by a competent oculist!

It is a rule—to which there are few exceptions—that, in addition to those defects which all eyes possess in common, the human organ of sight is, about the school age, prone to certain diseases, arising from inherent anomalies of structure, from heredity, from the results of infantile diseases, and from other causes. It is also true that many, if not most, of these dangers to which the eye in after-life is subject may be warded off by precautions suitable to individual cases. Thus the *myope*, or short-sighted person, should exercise care of a kind quite different from that which is suitable to the *hyperope*, or long-sighted individual; while the unfortunate astigmatic child (with "blurred" sight) should follow a prophylactic programme of a kind distinct from either; and so on through the list of possible ocular defects, which, although they commonly elude even the watchful eye of parent or guardian, are still possible sources of future disease. The advance of ophthalmological science has reached that point where one may read in the defective eyes of childhood the record of a large percentage of the impaired, restricted, or lost vision of later years.

MUSICAL INSTRUMENTS—THE ORGAN.

By DANIEL SPILLANE.

THE DEVELOPMENT OF AMERICAN INDUSTRIES SINCE COLUMBUS. XIII.

THE organ is the most magnificent and comprehensive of all musical instruments. While the pipes of Pan—aside from that mythical personage—indicate a very ancient use of pipes as a means of producing musical sounds, the "water-organ of the ancients" furnishes to the student of organ history the first tangible clew regarding the remote evolution of the instrument. In the second century the magripha, an organ of ten pipes with a crude key-board, is said to have existed, but accounts of this instrument are involved in much obscurity. It is averred that an organ—the gift of Constantine—was in the possession of King Pepin of France in 757; but Aldhelm, a monk, makes mention of an organ with "gilt pipes" as far back as the year 700. Wolston speaks of an organ containing 400 pipes, which was erected in the tenth century in England. This instrument was blown by "thirteen separate pairs of bellows." It also contained a large key-

board. There are drawings of that period extant, which represent the organ as an instrument having but few pipes, blown by two or three persons, and usually performed on by a monk. The keys, which were played upon by hard blows of the fist, were very clumsy, and from four to six inches broad. About the end of the eleventh century semitones were introduced into the keyboard, but to all appearances its compass did not extend beyond three octaves. The introduction of pedals, in 1490, by Bernhardt—giving a compass B flat to A—was another important contribution to the instrument. These were merely small pieces of wood operated by the toe of the player.

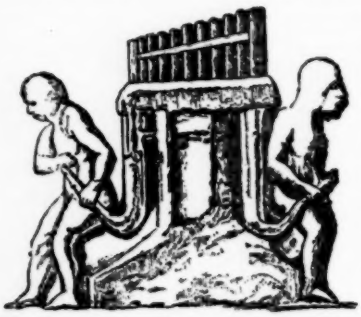

FIG. 1.—ANTIQUE SCULPTURE IN THE MUSEUM OF ARLES, dated XX.M.VIII, representing organ blown by the mouth.

Jordan's "swell organ," which was introduced about 1712, in England, is deservedly ranked as one of the greatest advances in organ-building known up to that year. Jordan was renowned among the builders of his century. Green, another noted English builder of the period, improved the swell and added a score of lesser innovations which give him a prominent place in histories of the instrument. Milton was cheered and consoled in his blindness, as we learn from his biographers, by a portable organ. This was a form of instrument called the regale, which was in use during the sixteenth and seventeenth centuries. It has, however, been obsolete for over a century.

From being a mere accessory to church choral services, the organ has been improved in time by the introduction of stops, instrumental effects, and the extension of pedal and manual compass, until it has attained such a recognized position as a solo instrument that it might now be called an orchestra in itself. In the last century the men notably associated as builders with its progress were Jordan, Green, Schroder, Silberman, Snetzler, Harriss, Avery, Bywell, and Father Schmidt. Frescobaldi, the organist, who wrote the first fugues and musical compositions according to the highest capacities of the organ in his lifetime (1580–1640), gave the development of the instrument a great impetus. Stradella, J. S. Bach, Handel, and Albrechtsberger followed as executants and composers of organ

FIG. 2.—REPRESENTATION OF AN ORGAN ON AN OBELISK AT CONSTANTINOPLE, erected in the fourth century.

music. Each of these eminent musicians assisted in the improvement of the instrument by suggestions given to the celebrated builders of his time. The builders of the seventeenth and eighteenth centuries were great enthusiasts in their art, and every fresh development in the region of tones and effects was introduced with considerable *éclat*. Of the old effects still in use, the Kremhorn (Cremona), the Gemshorn, and Hohl flute stops are most generally known. As we behold to-day the magnificent instruments in European and American churches and concert auditoriums from the workshops of the representative builders of both continents, we are given much to contemplate from a mechanical and artistic point of view, while the wonderful musical effects that they are capable of producing tend to fill us with awe and profound pleasure.

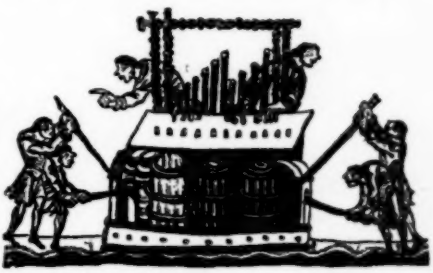

FIG. 3.—CURIOUS DRAWING FROM MS. PSALTER OF EDWIN, in the library of Trinity College, Cambridge, England.

Among the most famous of the old organs in Europe is the Haarlem instrument, built by Christian Müller, of Amsterdam (1735–'38). This is celebrated as one of the largest and finest in the world. It has a manual compass of 51 notes, CC to D in alt, and a pedal compass of 27 notes, CCC to tenor D. It has 60 stops and 4,088 pipes, divided as follows: Great organ, 16 stops, 1,200 pipes; choir, 14 stops, 1,268 pipes; echo, 15 stops, 1,098 pipes; pedal, 15 stops, 513 pipes. The chief accessory stops, movements, etc., are: (1) Coupler choir to great; (2) coupler echo to great; (3, 4) two tremulants; (5) wind to great organ; (6) wind to choir organ; (7) wind to echo organ; (8) wind to pedal organ—with twelve bellows nine feet by five. This magnificent instrument lacks the advantages of modern organs in the general action mechanism. The Haarlem organ can not be played without the expenditure of considerable muscular energy. The organist has to strip to his duties like a wrestler, and when the performance is over he withdraws covered with perspiration. Though endowed with wonderful musical effects in the extent and variety of its stops and combinations, these have been lost hitherto, owing to the disabilities of the manual and pedal action. Modern develop-

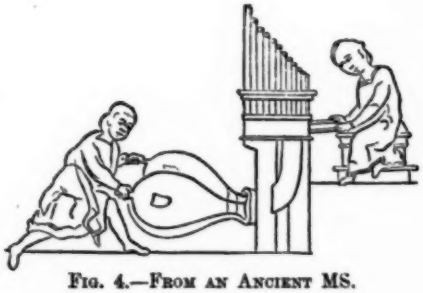

FIG. 4.—FROM AN ANCIENT MS.

ments in mechanics, and particularly the application of pneumatics, as shown in the magnificent American instrument by Jardine & Sons recently erected in the Brooklyn Tabernacle, have rendered the most complicated and extended *ensemble* effects capable of easy expression, while allowing the organist that amount of muscular repose necessary for the mental demands of his art.

The Spaniards brought over the first organs heard on this continent, but so little is known concerning the subject that the historic attempt of Thomas Brattle to introduce an organ into the King's Chapel, in Boston, in 1713, may be accepted as the earliest reliable contribution to American organ history on record. Brattle's organ is at present in St. John's Chapel, Portsmouth, N. H. Thomas Brattle, a native of Boston, after whom Brattle Street and Brattle Square are named, imported the organ referred to. He bequeathed it to the Brattle Street Church, provided "that within a year from his death they would procure a sober person who could play skillfully thereon with a loud noise, otherwise to the King's Chapel." Whether it was owing to the inability of the management of the favored church to procure a "sober person" capable of playing with a "loud noise" on that historic instrument—which is rather an aspersion on the ability of Boston organists of the time, as well as a reflection on their muscular capacity—or through prejudice against the instrument as an alleged agency of the evil spirit, matters little now; suffice it for the historian to say that it was refused. It was accordingly thrown over on the congregation of King's Chapel and practically sent begging an owner, for King's Chapel also refused to accept it. The executors of Brattle's will having done their duty in the order intimated, refused to cart it away, and after considerable discussion it was allowed to lie in the porch of the church unpacked. It rested there for seven months, until the question was reopened in 1714, ending with the erection of

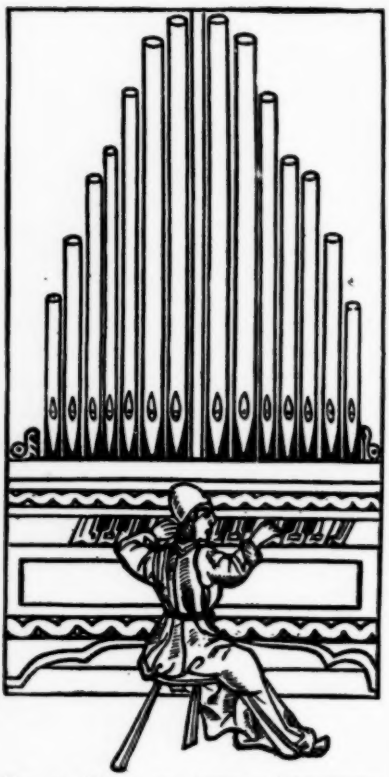

FIG. 5.—FROM AN ANCIENT ENGRAVING, showing early key-board.

the instrument. Here it was used from 1718 to 1756, when it was sold to St. Paul's Church, Newburyport. In 1836 it was transferred to St. John's, Portsmouth.

It has been generally accepted that Edward Bromfield, Jr., of Boston, built the first American organ, in 1745. The writer, however, is in a position to assert that, although a venerable piece of musical history, this is not a fact. Mr. J. W. Jordan, Assistant Librarian of the Pennsylvania Historical Society, who has paid special attention to the subject, recently discovered that Mathias Zimmerman, of Philadelphia, a carpenter and joiner, built an organ in that city some time before 1737. In his will, probated in 1737, he bequeathed the organ to a nephew, hoping that he would learn to play on it, adding that if not it could be sold to advantage, owing to its being so much of a curiosity. The record of Zimmerman's will forever disposes of the time-honored belief regarding Bromfield.

FIG. 6.—METHOD OF BLOWING DESCRIBED BY PRÆTORIUS; representing the old organ in the Church of St. Ægidien, Brunswick.

The Germans and Swedes were the chief organ-builders in America during the last century. In Pennsylvania, where several colonies located, no less than four organ-builders of note practiced their art from 1740 to 1770. These were Gustavus Hesselins, John Klem, David Tanneberger, and Robert Harttafel. Mr. Jordan, to whom I also owe the foregoing information, says the first named was a Swede. He adds in a communication, "Tanneberger's reputation as an organ-builder stood very high, and I know of at least one of his fine instruments still in use."

The Moravians of Bethlehem, in that State, were particularly noted for their connection with musical art during the last century, and their descendants manifest the same faculty. The annexed extract of a letter from Hesselins, of Philadelphia, to Rev. J. C. Pyrlaens, Bethlehem, May 28, 1746, has some value to students of national musical history: "I hope Mr. Klem will see the organ well and safe in your hands." The following is another record of a more explicit nature: "Received, June 9, 1746, of Jasper Payne, of Bethlehem, four pounds and three pounds for the half set of pipes, and one pound for coming and putting the organ up." (Signed) "John Klem, organ-builder." Franklin, in writing

to his wife, in 1756, remarks that he "heard very fine music in the church" (at Bethlehem), that "flutes, oboes, French horns, and trumpets accompanied the organ."

After Bromfield, the next organ-builder in New England was Thomas Johnston, who built an instrument for Christ Church, Boston, in 1752. He is known to have supplied the Episcopal Church in Salem with another organ in 1754, containing one manual and six stops. This pioneer maker died in 1769. Dr. Josiah Leavitt, a physician of Boston, became interested in the art through intercourse with Bromfield, with the result that he subsequently devoted himself to practical organ-building for many years, with a fair measure of success. The next organ-builder in New England after Johnston was Pratt, who went out of the business toward 1800. William M. Goodrich, a native of Templeton, Mass., born in 1777, began to build organs in Boston in 1803. He was a pupil of Leavitt, and was the first native-born organ-builder who achieved a worthy place in that noble art. Several eminent makers graduated from the shop of Goodrich, the principal being Thomas Appleton, many of whose instruments are still in use. Ebenezer Goodrich left his brother's shop and began organ-building in 1816 on his own account. He drifted into partnership with Thomas Appleton subsequently, but after a few years they separated. Thomas McIntyre, another early Boston builder of note, appeared in 1823. This maker also left many fine instruments behind him as examples of his skill. Though Goodrich, McIntyre, and Appleton accomplished much, taking into account their opportunities, the times they labored in, and the class for which they catered, the organs they built are insignificant beside more modern products of the Hook & Hastings, Erben, Jardine, and Roose-

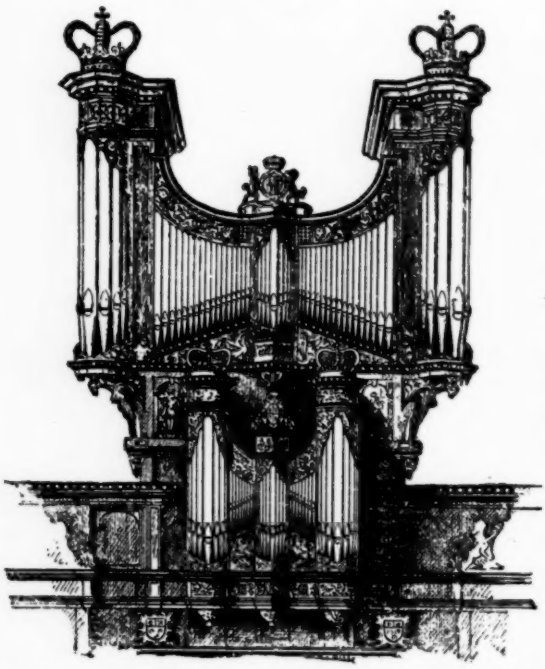

FIG. 7.—KING'S COLLEGE, CAMBRIDGE, ENGLAND. Built by Dallam, 1605–'6.

velt establishments. Meanwhile the development of organ-building in this country, it must be remembered, depended almost wholly upon the disposition of church patrons and clergymen to follow the example of their European brethren in giving the instrument a place in religious ceremonials. As evidenced in the Brattle incident, much prejudice formerly existed against the

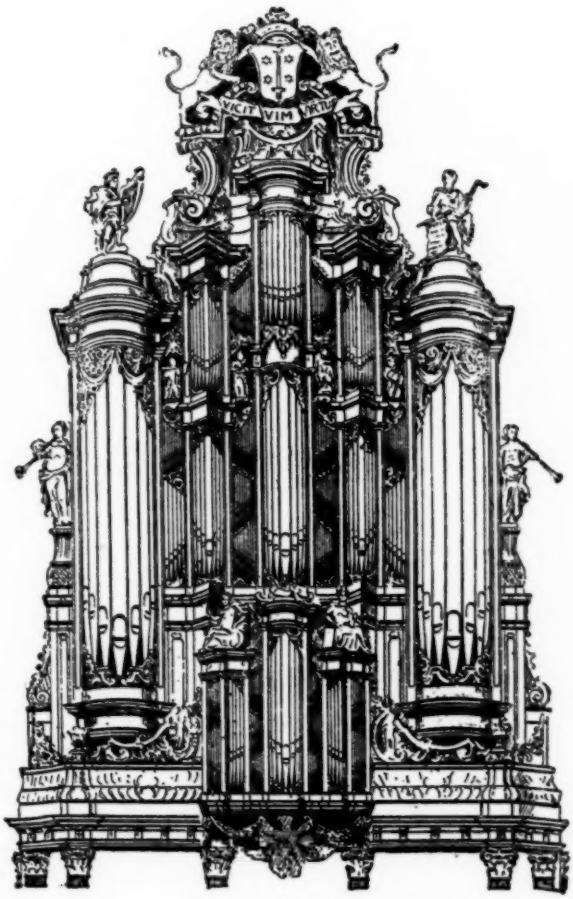

FIG. 8.—HAARLEM CATHEDRAL. Built by Müller, 1735–'38.

use of the instrument in church services among the Protestant sects—the predominating element—but, unless in very rural districts, none of this feeling now persists.

The Hooks, precursors of the celebrated firm of Hook & Hastings, Boston, were the first builders in New England to display individuality and a desire to adopt new improvements in their instruments. The Hook brothers, Elias and George G., began business in Salem, Mass., in 1827. Elias, the practical head of the

business, was, like Appleton, a graduate of the elder Goodrich's establishment. Winning notice toward 1832, they removed to Boston, and there entered on a remarkable career, in time forming the firm of Hook & Hastings, now known throughout America as organ-builders of the highest rank. Hook & Hastings came into being in 1865, through the accession of Mr. F. H. Hastings, an expert workman and a graduate of their shop. The Hook brothers died within a year of each other, George C. Hook passing away in 1880, at the age of seventy-three; Elias, the founder of the house, in 1881. The business thereupon devolved on Mr. Hastings, who has conducted it since then with much success. Evidences of the great skill of Hook & Hastings are scattered all over the continent. Among their important instruments may be mentioned the organ in Music Hall, Cincinnati, built in 1878, which is one of the largest in the country. The Tremont

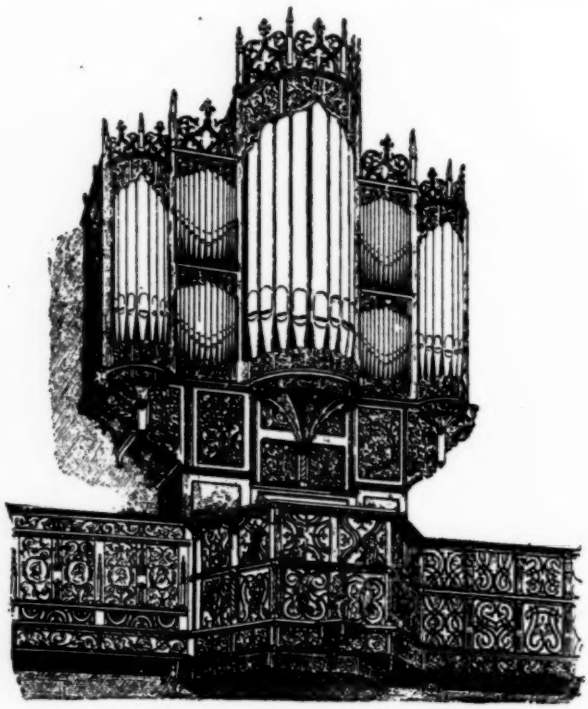

FIG. 9.—MARIEN KIRCHE, DORTMUND.

Temple organ in Boston, remarkable for its artistic qualities, although smaller than the Cincinnati instrument, is another notable product of this firm. Visitors to the Centennial Exhibition in 1876 may remember the magnificent instrument in use there; this was also supplied from the same establishment. These instruments are equipped with every mechanical and scientific de-

vice requisite for bringing their immense resources under control of the organist. Mr. Hastings, while adopting many innovations from European sources, improved upon them materially in his method of application; his coupling and draw-stop system, in particular, being most sympathetic and effective in operation. These organs possess remarkably well-balanced tonal qualities also, being free from the prevailing acoustic defects apparent in large instruments of some makers.

Organ-building, like all the arts, was encouraged in New York to a greater extent than elsewhere in the years preceding the Revolutionary War and immediately afterward. The spirit of

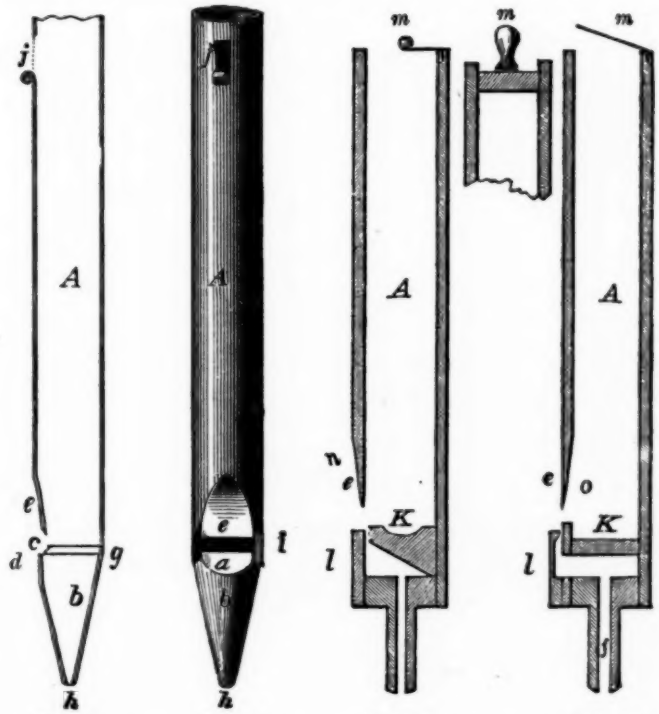

Fig. 10. Fig. 11. Fig. 12. Fig. 13.

Figs. 10 and 11.—Flue-stop Pipes, showing general features of construction: body of pipe (*A*), foot (*b*), mouth (*c*), lower lip (*d*), upper lip (*e*), air passage (*f*), languette which divides the body of the pipe from the foot (*g*), wind entrance (*h*), ears for steadying the wind (*i*), and tuner (*j*). Figs. 12 and 13 represent section of a wood pipe of the same order: the difference is shown in block (*K*), cap (*l*), tuner (*m*), exterior bevel (*n*), inverted mouth (*o*).

liberalism found its expression in the practices and observances of church bodies, too, and a desire to erect imposing organs in keeping with the custom obtaining in English communities was manifest. Geib, who built the old Grace Church instrument, was censured severely at the time of its construction for his inability to complete an organ of more massive proportions and capable

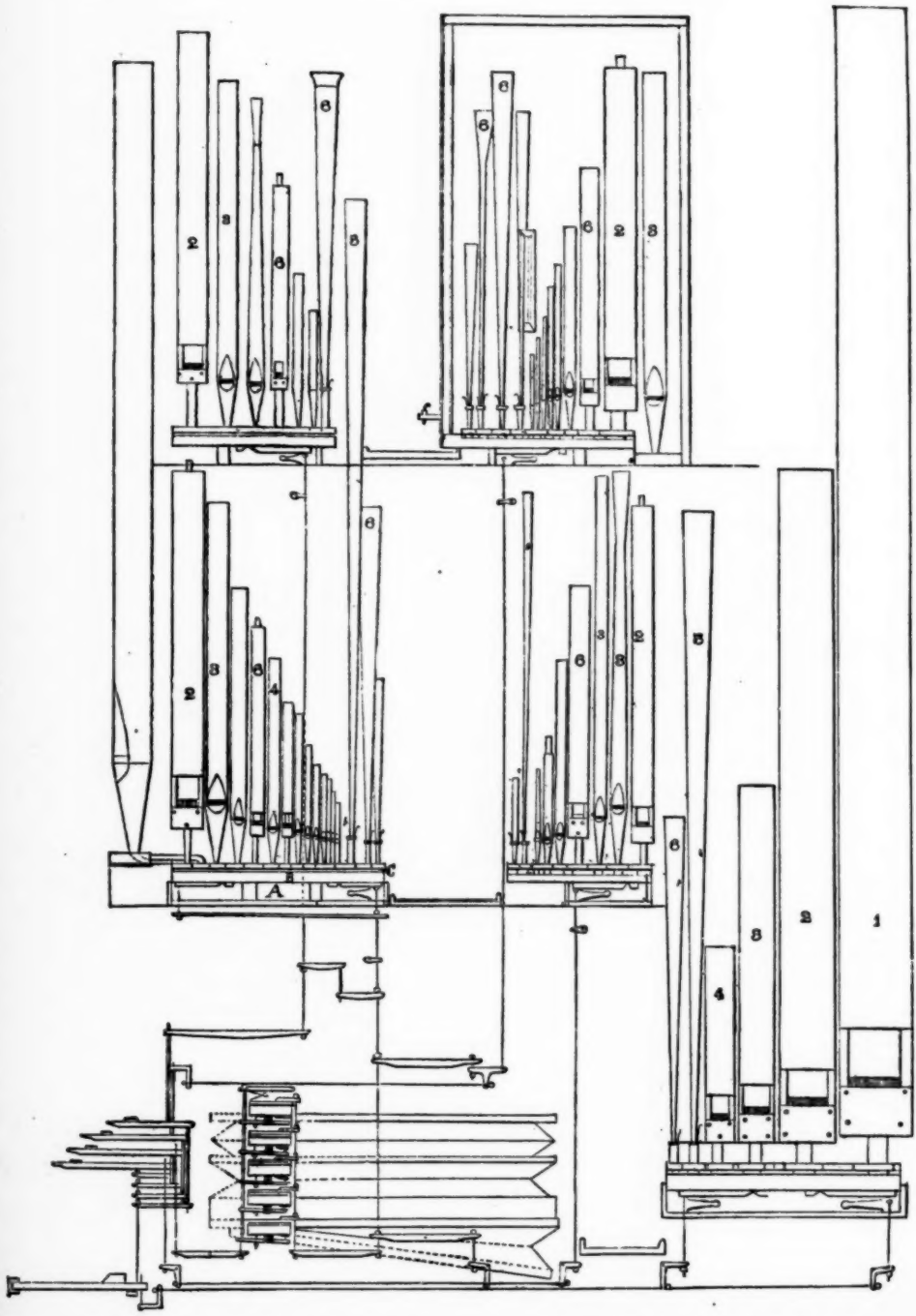

FIG. 14.—GENERAL PLAN OF A FOUR-MANUAL GRAND ORGAN (St. Patrick's Cathedral, New York), showing wind-chest of great organ (*A*), sound-board (*B*), and sliders or registers (*C*). (For further exemplification of action principles see Fig. 15.)

of more extended effects. It was the original intention of the patrons of the church at that period to have an instrument equal to some of the famous organs abroad; but Geib and his contemporaries would not undertake what they looked upon as an impossibility to them with their limited facilities and limited capacities. There was then talk of bringing over an instrument from London; but Geib's friends succeeded in putting the contract in his hands, satisfied to accept the best results he could produce. In the mean time the money saved was put to other account, so the story goes. Certain it is, however, that the first notable examples of the art of organ-building were produced in New York. Adam Geib, the builder referred to, came to New York in 1760. In that year he began business on a very unpretentious scale, but attained some note soon after the conclusion of the war. He was succeeded by two sons. John E. Geib, the best known, remained in the business until past 1830, and was looked upon as a very skillful builder.

Loew and Hall were builders of some mark in years past. The first named erected a fine instrument in St. John's Chapel. Hall served his apprenticeship with Loew, and was, in a minor sense, an originator and inventor of note. Hall was in business in New York from 1812 until 1875, when he passed away, at the age of eighty-five. A noted individual came forth from the workshop of Thomas Hall, during the early days of his business career, in the person of Henry Erben. Erben was such a remarkable youth that he was taken into partnership by Hall in 1827, just after concluding his apprenticeship. Separating from Hall in a few years, he established a business of his own in New York. Erben was fortunate enough to secure the contract for the organ in Trinity Church during his first labors, and this brought him reputation and status in his art. It is by no means a remarkable instrument, though of large proportions. Erben's later efforts were indicative of more originality. He introduced some improvements in the disposition of the general action of the instrument about 1860, which, though credited to him largely as his own inventions, were nevertheless adaptations of ideas copied from abroad.

Jardine & Sons, of New York, have taken out several important patents for organ improvements, besides constructing instruments of rare excellence embodying a hundred features of originality of the unpatentable order. In applying pneumatics to the action of the organ they have been particularly successful. Their patent pneumatic vacuum and tubular systems, also methods for controlling the registers by piston-knobs, are singularly effective devices. These are intended to facilitate execution, while rendering the manual and pedal actions easy and

sympathetic to every demand of the artist. Mr. A. J. Hipkins gives the following account of the introduction of pneumatic action, the most valuable of modern developments, in the organ: "The late Mr. Joseph Booth, of Wakefield, was the first organ-builder to whom the idea seems to have occurred of establishing

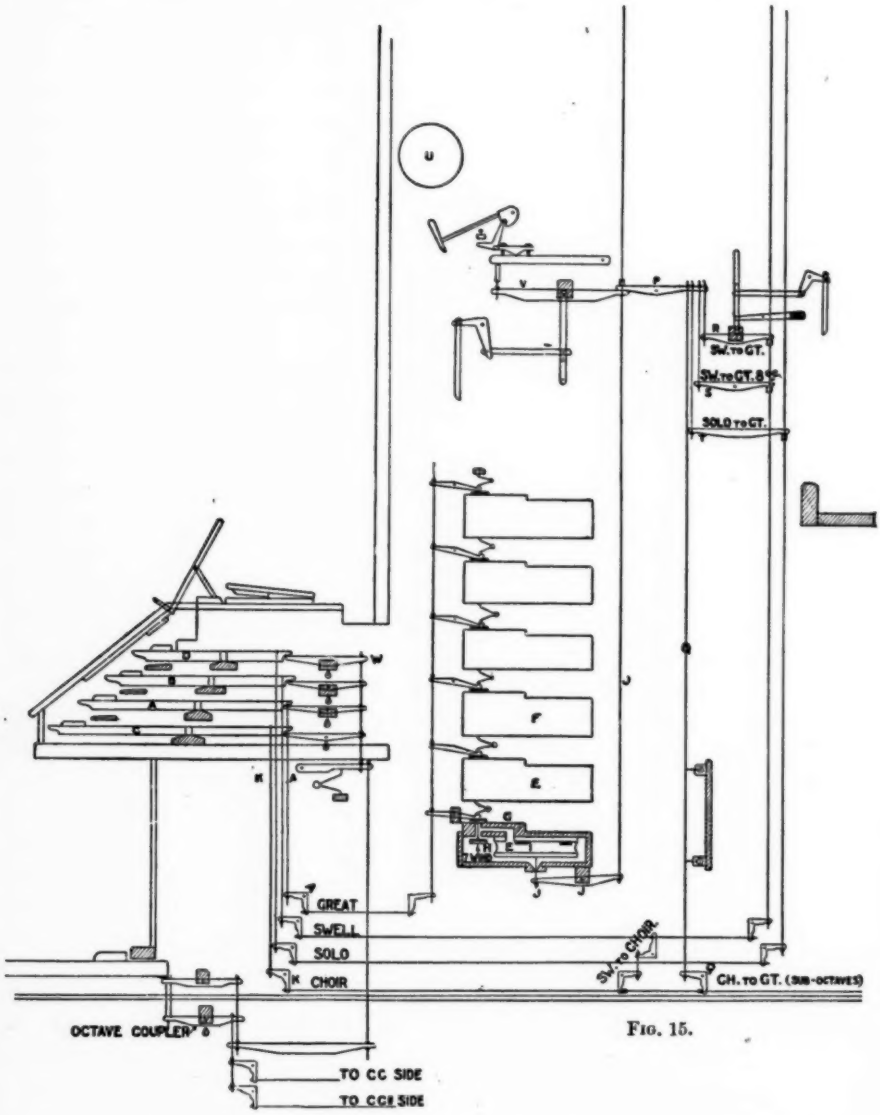

FIG. 15.

pneumatic agency, and of thus ingeniously turning the wind-power, one of the organist's antagonists, into his assistant." (Mr. Hipkins means the pressure of wind which impedes touch through the pallets, not the wind-power through which sound is

produced.) "It was to some of the bass pipes of the organ he built for the Church of Attercliffe, near Sheffield, in the year 1827, that Booth first applied his little invention. The lower notes of the wood open diapason of the GG manual were placed on a small separate sound-board, and to the pull-down of each pallet he attached a small circular bellows underneath. From the great organ sound-board groove a conveyance conducts wind into this bellows, which, opening downward, draws the pallet with it. These small bellows Mr. Booth used to call 'puff-valves.'"

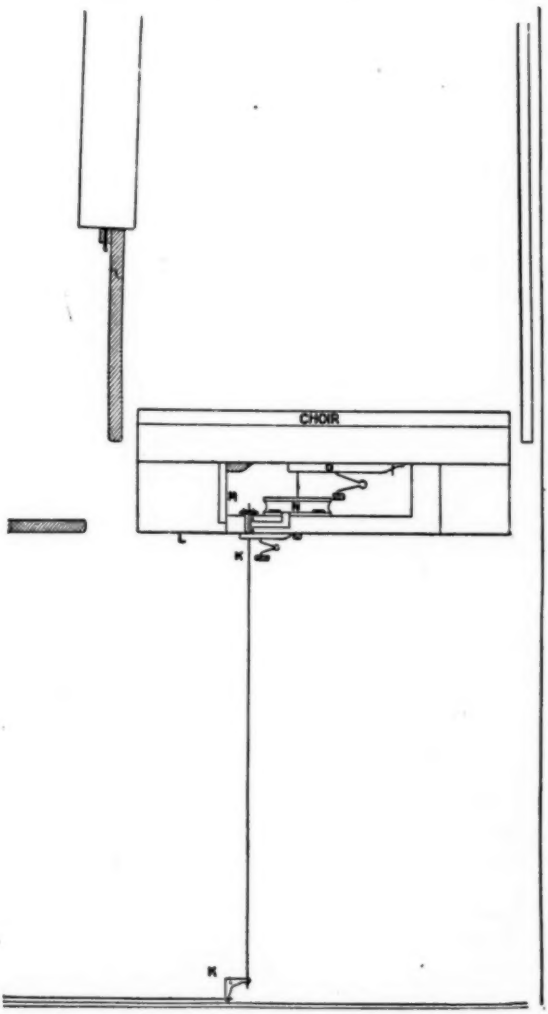

FIG. 15.—SECTIONAL VIEW OF ORGAN IN THE BROOKLYN TABERNACLE, illustrating the pneumatic and general action principles embodied (erected 1891). The great organ key-board in the above cut, also trackers and connections, are indicated by *A* throughout.

Since Booth's experiments in this direction many European builders, among them Cavaillé-Coll, of Paris, have contributed to the application of pneumatics, with the most remarkable results. American builders have not been behindhand either in adapting and improving upon the inventions of their contemporaries abroad, and their work is to be found illustrated in the magnificent instruments erected in various cities throughout the States. Jardine & Sons are admitted a leadership by the fourscore and odd organ-builders who constitute the business in the United States and the British Dominion. The founder of this eminent house, George Jardine, was born in Dartforth, England, November 1, 1801.

He learned his business with Flight & Robson, the famous English builders, and proved a workman of rare ability. In 1837 he arrived in New York, bringing over his family with him. American organ-building was in an embryo state at the time, and Jardine was compelled to put his mechanical skill to account in other directions; but he found an entry into the business in due time. Working along in an unpretentious way, he awaited an opportunity to show his ability. The Church of St. James gave him a contract for a small instrument, and the outcome laid the basis of his fortune. E. G. Jardine, his son, who had been educated to all the niceties and comprehensive details of the business, was taken into partnership in 1860, and upon the death of his father became the head of the firm. This gentleman has traveled extensively in Europe, where he studied the celebrated works of Cavaillé-Coll and other noted builders to acquire a broader insight into his art. During recent years Jardine & Sons have erected the following instruments: Fifth Avenue Cathedral, St. George's, St. Paul's, M. E., Holy Innocents, New York; Pittsburgh Cathedral, Mobile Cathedral, Christ Church, New Orleans, and the Brooklyn Tabernacle organ, all these being four-manual organs, besides a vast number of other notable instruments, which can not be specified here. George Jardine died in 1883, leaving a name destined to live among the world's greatest organ-builders of this century.

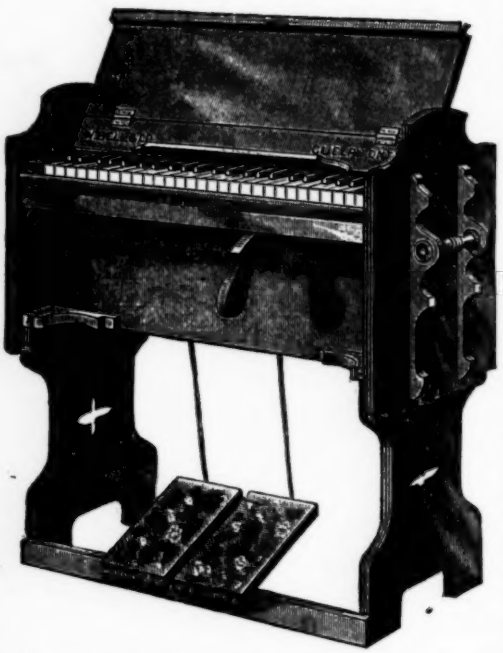

FIG. 16.—EARLY PRECURSOR OF THE AMERICAN PARLOR ORGAN.

The present condition of the art of organ-building in America is further exemplified in the magnificent concert instrument erected in the Auditorium Building, Chicago, by the Roosevelt house of New York. Hilbourne L. Roosevelt, the founder of this house, was a native of New York, who was educated to a scholastic pursuit. Interest in the instrument as a boy led up to an enthusiasm for the mechanical and artistic possibilities which it em-

bodied, and believing himself capable of contributing to its perfection, Roosevelt entered the sphere of organ-building with love for the art, personal genius, and money to back up his ambition. Though cut off prematurely in 1889, he had succeeded in winning fame as an inventor and builder of the highest character. The instrument designated alone proves the capabilities of the house and the value of the mechanical and scientific principles which Roosevelt developed and helped to put into practical effect. Among his numerous innovations, which created considerable interest and discussion, was his arrangement of the swell effect. For instance, in a two-manual instrument of ordinary dimensions and capacity he inclosed all the pipes in a swell-box of his own construction and design, which enabled the executant to produce better *nuances* leading from *forte* to *piano*, or *vice versa*; at least, the champions of the Roosevelt system asserted these claims, while there was also a strong opposition among organists to that method of construction. I think, however, that the Roosevelt system will prove a valuable feature in time; at present it is somewhat immature and crude. Mr. Roosevelt also carried the principle into the region of three and four manual instruments. In the latter almost all the total register of tones can be brought under the influence of the swell at pleasure. This is accomplished by inclosing the various organs, solo, etc., constituting the abstract instrument, in separate swell-boxes, part of the grand organ being also partly inclosed. Apart from his original departure in the swell movement, Mr. Roosevelt introduced several notable improvements in the action of his three or four manual instruments. In the application of electricity and pneumatics to the instrument as well as in the region of tones this maker further displayed his remarkable ability. The Auditorium organ is an eloquent illustration of Roosevelt's capacity; the Garden City Cathedral instrument is another magnificent example of what the Roosevelt shop was and is capable of accomplishing. Though the late Mr. Roosevelt was the genius of the house he founded, the business is still carried on with success on the lines he laid down.

Johnson & Sons, of Westfield, Mass., are known as capable and progressive makers, destined through their past work to reach a high position in the future. William A. Johnson, the head of the business, has brought forth many inventions of value. In the region of voicing—a most important function—his son, W. M. Johnson, is regarded as an expert of the first order. Hutchings, Plaisted & Co., another Boston firm, have won considerable notice for their instruments within the past twenty years, many of which contain improvements of value, and are found in leading churches throughout the country.

The general principles of the Jardine Tabernacle organ shown

in the accompanying plan will give the reader an idea of the modern improved organ, its wonderful mechanical and acoustic features, which involve such interesting complications of pipes, sound-boards, bellows, and draw-stop, mutative stop, manual and pedal action, through which one individual—the organist—can control a great domain of musical resources at one time.

The present organ is in singular contrast with the organ of

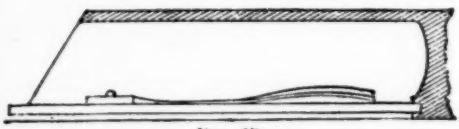

FIG. 17.

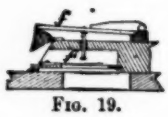

FIG. 19.

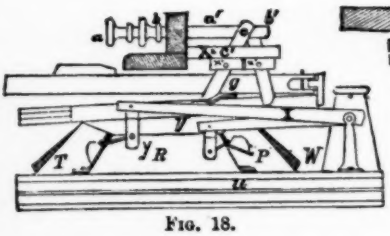

FIG. 18.

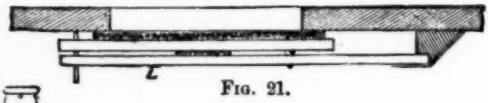

FIG. 21.

FIG. 22

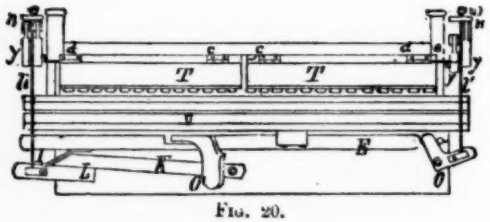

FIG. 20.

FIGS. 17 TO 22.—REPRESENTING CONSTRUCTIVE PRINCIPLES OF A MASON AND HAMLIN ORGAN. Fig. 17 shows position of reed; Fig. 18 represents in sectional elevation part of one end with reed-valves and stop action; Fig. 19 shows auxiliary mutes; Fig. 20 exhibits method by which the stop-valve is mounted: wind-chest (*U*), reed-valves (*I*), stop-valves (*T*), swell-cap (*V*) with the swell-lids attached (*W*), stop-lever (*X*), transverse roller-lever (*b'*), roller-board (*c'*), name-board (*a'*), draw-stops (*a* and *b*), and the tube-board (*R*). Some connections of the parts are indicated thus: The inner end of stop-valve (*T*) attached to tube-board (*R*) by butt-hinge (*c*); similar hinge (*d*) fastened to outer end of tube-board; stop-valve (*T*) joined to half hinge (*d*) by the bent wire (*e*); connection of bent wire (*e*) with stop-lever (*X*) by the link (*y*); brass incline (*g*) on stop-lever (*X*); also connection of stop with valve (*P*) at the back of tube-board (*R*). Figs. 21 and 22 represent relative parts according to exemplification.

past centuries. As a musical instrument, presided over by one mind, it is incomparably ahead of any other musical medium known, in the extent of its development, aside from its capacities in the artistic sphere. To dwell for a while upon its construction: Pipes in the organ are of two kinds, wood and metal, and of two acoustic classes—namely, reed and flue. The grouping and arrangement of the huge body of pipes which enter into the compo-

sition of large organs—many of them containing over six thousand—so as to get them under the command of the narrow compass of the manuals, reveal wonderful ingenuity, quite apart from the musical effects capable of being represented through the instrumentality of that noble art medium. Formerly the pipes were attached to one key-board. Then came the disposition of the pipes with two manuals and two cases. These were consequently termed double organs. A modern instrument is found in many instances to contain five separate organs within its case, but being all under the control of the organist, they are spoken of compositely as one instrument, though particularized in giving a description by their names—grand, swell, solo, choir, and pedal. Emphasis has been laid on these points in order to give readers a clear idea of the terms used elsewhere in speaking of the instrument.

Fig. 23.—Popular Style of Modern Parlor Organ.

The aim of the organ-builder has been to increase the variety and extent of the sounds, so as to render them available for art purposes through the instrumentality of the key-board and pedal system. And in the order of things, when the number of pipes was added to from time to time to give increased compass, it became necessary to originate improvements in the wind collecting and distributing departments. These are, first of all, the bellows, then the wind-chest, wind-trunk, and sound-board grooves. Meantime it is seen that the perfection of this department, so to speak, was such that it permitted the builder to apply air to the action mechanism according to the laws of pneumatics, with obvious advantage. In the early centuries the instrument was blown with a rude bellows by hand; then came the pedal bellows described by Prætorius, in 1620, which he found in the ancient organ in the church of St. Ægidien, in Brunswick. This system re-

ferred to—working them by the feet, the blowers holding on to a rigid transverse bar as they moved along the row (the bellows described by the authority named numbered twenty, and were operated by two men)—was, however, known a thousand years previous, in Constantinople. Passing over incidental contributions to that department, it is only necessary to point out that the demands upon the wind became so great in time that it was deemed necessary to introduce mechanical means for supplying and regulating the supply required. A hydraulic engine, invented by Joy and Holt, of Middleborough, England, though defective in some respects, was the first thing found to answer the purpose. Next came a water-moter, invented by Thomas Duncan, which met with some favor. Latterly, gas and electricity have been applied with much success, and in the operation of the most comprehensive organs little difficulty is experienced at present in supplying and regulating the stock of wind required.

When the organ-builder increased the compass of the instrument and its effects, the perfecting of the key movement, the invention of the draw-stop action for controlling the use of the various tiers of pipes, the introduction of composition pedals, couplers, and other features became necessary as a part of the major development, viz., the modern great organ as it stands. Of electricity and pneumatics nothing more need be said save that these agencies have been found invaluable in operating massive instruments.

A description of the Tabernacle organ in Brooklyn will show the mechanical and scientific points of interest contained in a modern instrument of that class: The great-organ key-board (A) is capable of controlling all the others—namely, swell (B), choir (C), and solo organ (D). In effect, the great-organ key-board through the tracker (A) and squares (A) opens the ports of the pneumatic chest (E), the interior of one of which is shown. This is filled with compressed air of a power and quantity capable of raising a column of water seven inches. When the key is pressed, or operated, it opens the vent-valve (G) and closes the supply-valve (H). The compressed air from the chest presses on the top of the small bellows (I), one of which is furnished to each note, and the wind, consequently escaping through the vent-valve, *pulls* the wire of lever (J) and tracker (J). This passes up and pulls open the big valve in the great-organ wind chest, and affects all the other organs also, when coupled on to the tracker indicated.

To explain the action of the choir key-board (C): On being pressed, the key (C) opens the train of trackers and connections (K); the vent-valve (L) in that chest is opened, which closes the supply-valve (N), thereby allowing wind to escape from the small

pneumatic bellows (N), which, being pressed down by the force of compressed air from the wind-chest, opens the large valve (O). This supplies all the pipes in that chest with wind. The swell (B) and solo (D) key-boards also operate their respective wind-chests on the same principle.

The couplers are operated through the medium of lever (P), which is controlled through a block glued on the tracker (J). When the performer desires to couple the choir to the great organ, the draw-stop pulled out has the effect of pushing the square (G) up against the tracker (K), when the desired result is attained. Again, when he wishes to couple the swell to the great, the pulling out of the draw-stop brings up the lever (R) against the block on the tracker in that connection. The coupling of the swell octave is attained by the levers (S), which are placed at an angle so as to pull the tracker of the swell one octave higher, by an ingenious movement. In coupling the solo organ to the great, the lever (T) is moved up to the block on the tracker of that manual. A little study of the plan, and the points given, will explain the general system of action very clearly. In this instrument a set of bells of three octaves (U) are operated from the great-organ key-board by a mechanism of the square piano order; pneumatic agency is also used here, as the pressure of the key will not of itself furnish the dynamic impulse necessary to put them in vibration. This is attained by a draw-stop, which puts lever (V) and tracker (J) in connection by pushing the former up against the latter. To play any of the key-boards by pedals, a "cam" serves to raise the levers (W) to the tail of the keys, thus establishing a connection.

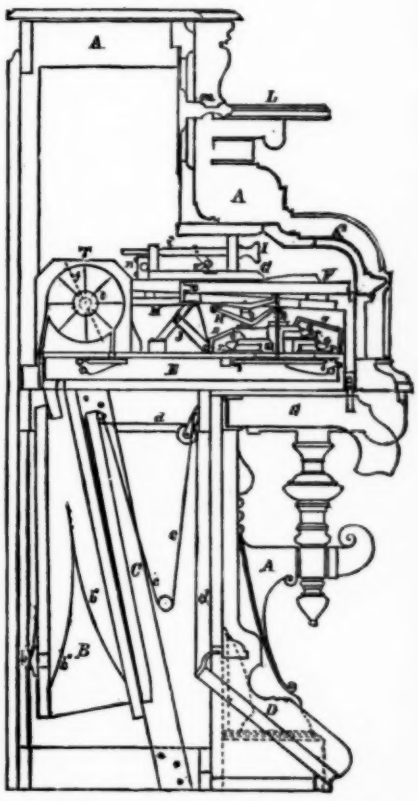

FIG. 24.—GENERAL VIEW OF INTERIOR OF PARLOR ORGAN (Estey system).—Case (*A*), lid to key-board (*A''*), bellows reservoir (*B*), escapement (*b*), treadle (*D*), tape connecting *D* with *C* (*d*), wind-chest (*E*), reed-socket (*e*), reeds (*r r*), dampers (*s*), swells (*s*), octave-coupler levers (*H*), tracker-pin (*h*), key (*F*), name-board (*G*), stop-knob (*I*), stop-rod (*i*), lever and link for swells (*J*), slide for opening dampers (*M*), grand-organ roll (*n*), vox humana tremolo (*T*), float-wheel of tremolo (*t*), fan (*f*), music-support (*m*), lamp-stool (*L*), and knee-swell lever (*S*).

Among the special effects in this organ not specified are a bass-drum and tympani (kettle-drums), also operated by pneumatic agency. The great and swell organs are on a four-inch wind; the choir is on a three-inch; the thirty-two-foot and sixteen-foot open diapasons are on a seven-inch wind. In the region of tones may be found a German gamba—a unique stop with a string tone—and a *vox humana* copied from the celebrated instrument at Freiburg by Mooser. The *vox anglica* in the organ treated on is a remarkable expression effect, while the song-trumpet stop is a startling acoustic development. It is of such immense power that it is capable of leading eight thousand voices. The instrument also contains combination piston-knobs under the key-board and a combination pedal to every organ. These are adjustable. There are in all 110 stops and 4,448 pipes, divided as follows: Great organ, 18 stops, 1,464 pipes; swell organ, 18 stops, 1,342 pipes; choir organ, 12 stops, 854 pipes; solo organ, 8 stops, 488 pipes; pedal organ, 10 stops, 300 pipes; also 10 couplers, 11 mechanical movements, 6 pneumatic piston-knobs in great organ, 11 combination pedals, and 6 pedal movements.

The four manuals contain five octaves each, with an auxiliary pedal compass of two and a half octaves. The wind is furnished by three immense bellows of various wind pressure, operated by a C. & C. electric motor of an improved order on an Edison circuit. Its exterior, moreover, is most striking. It shows a façade of richly decorated pipes forty feet in width and fifty feet in height, and is altogether one of the finest instruments in appearance and effect in this country, and an imposing exemplification of American organ-building.

THE PARLOR ORGAN.—Sound is produced in instruments such as the French and English harmonium and the American parlor organ through the medium of the free reed. The latter, though related to the former in a physical and mechanical sense, is in many respects so different from the European reed instruments of the class designated that it is entitled to stand alone as an instrument peculiarly American and distinct in point of construction.

The individuality of the American parlor organ rests largely upon the system of reed structure invented in this country, upon which a tone has been evolved which is easily distinguished from that produced by the reed instruments made abroad. Several other features in its interior construction and exterior finish, however, distinguish it from the reed instruments called harmoniums produced in Europe. The "free reed," as it was first applied in American accordeons and seraphines, was not by any means a domestic invention, as writers recklessly assert. It was used by European pipe-organ builders for stop effects, and also in a sepa-

rate key-board instrument, prior to 1800. The "free reed" is so named to distinguish it from the "beating reed" of the clarionet and the "double reed" of the oboe and bassoon. It consists of a strip of flexible metal adjusted on a pan over a slot in which the reed vibrates on being set in motion by a current of air, thus producing a musical sound. Pitch, the height or depth of sounds, is regulated by the size and structure of the reed and pan, the smaller reeds producing the sharpest and the larger the gravest tones, while *timbre*, or quality, one of the three chief characteristics which a sound possesses, is conditioned by the structure of the reed, the nature of the metal used, and other incidental influences.

The seraphine was the first instrument of the class produced in America. It was invented by Mr. Chadwick, an American, and was merely a slight advance on the accordeon, its precursor, which was also a key-board instrument. The melodeon appeared about

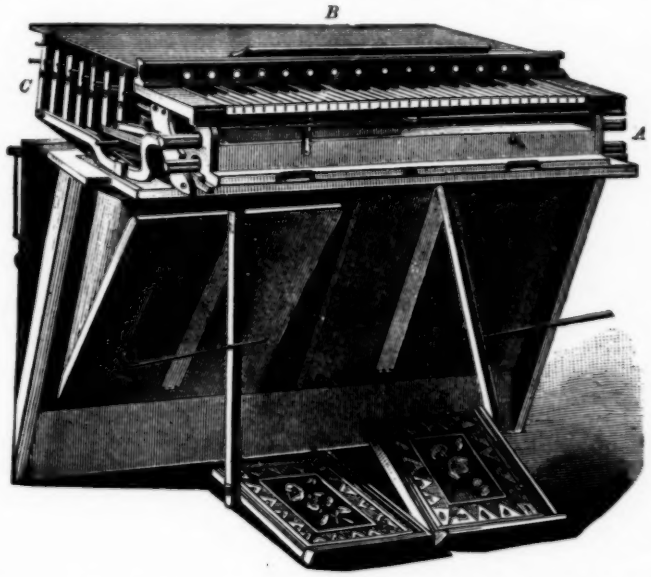

FIG. 25.—SHOWING BODY OF ORGAN REMOVED FROM CASE (Peloubet system, Lyon & Healy, Chicago, manufacturers).—Ends of mutes belonging to two full registers of reeds (*A*); stop-board (*B*), with knobs in front; upright forked levers for stops (*C*). Also illustrates general principles.

1840, and differed little from French harmoniums until Emmons Hamlin—afterward one of the founders of the celebrated firm of Mason & Hamlin—introduced some significant improvements in the construction of the reed. The improvement was of a highly important character from the historical point of view, since it was the first and chief step toward the American parlor organ. Hamlin found that, if the tongue of the reed were slightly twisted or

bent, a better quality of tone could be produced. This discovery was made in 1848. Subsequent experiments yielded remarkable results, and a new instrument was practically introduced. Meanwhile the discovery of the method of reed structure referred to has been a subject of dispute for years, the late Mr. Riley Burdette and others claiming to have anticipated Hamlin. As neither took out a patent, I can only give the version most generally accepted. In 1847 the two leading American firms devoted to the melodeon were Prince & Co. and Carhart & Needham, both located in Buffalo, N. Y. Hamlin was a clever workman and tuner in the employ of Prince & Co., to whose benefit he turned his discovery up to 1854, when he joined the celebrated Dr. Lowell Mason and founded the eminent Boston firm yet bearing their names. Other makers were not slow to copy the invention, and it became a commonly accepted principle in the melodeon within a few years.

The use of these instruments became wide-spread from 1850 upward, many patented improvements being brought forward in the interval in the acoustic and other departments. Of these, Jeremiah Carhart's invention of the exhaust or suction bellows in 1846 was the most significant. Harmoniums, so called, were also produced in this country similar to those of Alexandre, of Paris, but they varied little from seraphines and melodeons except in matters of detail. Carhart's bellows became generally adopted subsequently, and at this period is used exclusively in American organs. The old method of playing air upon the reeds yet obtains in Europe, owing to the claim that it secures more prompt speech, while the opposite method is employed in this country.

Toward 1861 the first instruments resembling the modern parlor-organ appeared. The case became individualized, new tone effects were added, two or more sets of reeds employed, and the name of "organ" applied formally. Mason & Hamlin first used the term in instruments of that improved order in 1861 which they named "organ harmoniums," to distinguish them from melodeons and harmoniums. In a few years it became "organs." Prince & Co., Carhart & Needham, and other makers contributed to the later developments in special directions, but to the firm of Mason & Hamlin is conceded the claim that they were the first to introduce the parlor organ in the year designated.

The organ business grew so rapidly that a great many new firms entered the field before 1870, some of them yet existing. Among the older houses yet devoted to this industry are Clough & Warren, of Detroit, and Estey & Co., of Brattleboro, Vt., both being founded about 1850. In the organs of both of these firms technical and acoustic ideas of a special nature are to be seen. This must also be said of instruments produced by more modern

firms. But in the abstract the organs produced by the leading makers approximate in most respects, all aiming after the same artistic results. The most elaborate and costly organs, however, come from the workshops of Mason & Hamlin, who deserve special recognition for their untiring efforts to elevate the instrument in artistic character and status. The present head of the firm, Mr. Edward Mason, is a grandson of Dr. Lowell Mason, and a native of Boston, where he was born in 1858. The founders of the business have all passed away.

FIG. 26.—IMPROVED MODEL, WITH TWO MANUALS AND PEDALS (capable of fine artistic effects).

There are many other excellent organ-makers in the United States, some of whom are better known in Europe than in this country, strange as it may seem. The number of organs exported annually is very large, and of these the West contributes a goodly share.

The manufacture of reeds, keys, and many other parts of the instrument became specialized as in the case of the piano, but not to such an extent The Munroe Reed Company was the most important of these specialists, the others being largely associated with the kindred industry of piano-making.

Improvement in the organ since 1850 has been expressed in the development of tone and case structure, as remarked, while the chief patents taken out have been for mechanical contrivances to cheapen production. Modern parlor organs represent considerable intelligence and accumulated effort in their scope and character, many of the examples produced coming close to the smaller

pipe-organs in effect. Quality of tone, together with power and great variety, are now possible, whereas the harmoniums, melodeons, and seraphines known in 1860 were simple instruments with one set of reeds and no stops worthy of the name, being only fit for domestic hymn-singing. Notwithstanding, the organ has ceased to be popular at present, nearly all the firms named having added the production of pianos to their business. The latter instrument has been growing into popular favor, to the disadvantage of the former, and if present indications are reliable the production of organs will be an insignificant branch of industry in the future; yet some look forward to the re-establishment of the organ in popular favor.

Many attempts have been made to combine reeds with strings in the piano, the first being made by Prof. Wheatstone, in London, in 1834. Obed Coleman, a native of New Bedford, Mass., invented a system for uniting both in a square piano, which he named the Æolian attachment. This was adopted by a Boston manufacturer in 1844, but was abandoned after a few years. Other attempts have been made, with like results.

Organs combining the features of the pipe and reed have been also made, the Peloubet system being regarded as the most successful. Lyon & Healy, of Chicago, manufacture the "Peloubet reed-pipe organs" at present, their trade extending to Europe largely. Another form of organ somewhat approximate is the Vocalian. The physical basis of sound production in this instrument resembles that of the human voice, according to its inventor, Dr. Hamilton, a Scottish gentleman, who produced it after many years of study and experiment. The instrument consequently attracted much attention when introduced here in 1882. It comes very close to the pipe-organ in quality, and is an excellent substitute. Mason & Risch, of Worcester, Mass., manufacture these instruments.

Mechanical instruments called organettes are also produced in large numbers for export and domestic purposes. In these, sheets of perforated paper run over the reeds, the perforations admitting free play for the air, thus producing the desired effect. They are of American invention. Organs employing somewhat similar methods for the mechanical production of music by pneumatic action have come into use recently, but, while capable of yielding pleasing effects, they are decried by musicians, upon the ground that the individuality of an artistic musical performance can not be duplicated apart from human instrumentality. This is, however, only a matter of opinion. While the majority of organ manufacturers are scattered throughout various States—unlike the piano art industry, which is mostly concentrated in New York and Boston—Chicago is the largest producing center in the country.

MORAL EDUCABILITY.

By EDWARD PAYSON JACKSON.

FOR a long time the brain has been accepted, popularly as well as scientifically, as a gauge of intellectual capacity; less widely it has been known as an equally accurate gauge of physical and also of moral energy. If narrow compass and few and shallow convolutions in what are known as the intellectual "areas" infallibly indicate mental deficiency, the same conditions in the moral areas as infallibly indicate moral deficiency. It is a hard saying, but, whatever bearing it may have upon the doctrine of free moral agency and personal responsibility for action, it is as true as it is hard.

But there is a great difference in the results of feeble or arrested development in the three different sets of brain areas. Each case is attended with disadvantages peculiar to itself; only in the case of the moral areas are these disadvantages looked upon as "penalties." If the physical basis of intellect is ill developed, the subject may be doomed to obscurity, neglect, and perhaps hard manual labor for his livelihood; if the ganglia which supply his muscles and vital organs with nerve-force are small and weak, he must suffer life-long invalidism; in either case he is simply "unfortunate"; but if Nature has allowed him only an ill-developed physical basis for the moral faculties, his unhappy deficiency is visited with the abhorrence and indignation of his fellow-men; he is a criminal, and he must suffer the "just punishment of his misdeeds" in prison or on the gallows.

Whether these differences involve an element of injustice on the part of Nature or her controller, or on the part of man, is not our question. Suffice that they exist, and that they are, in a measure at least, inevitable, since society does not need to be protected from the mental or the physical imbecile as it does from the moral imbecile. Both justice and policy demand, however, that the chief motive and purpose of society in dealing with the moral imbecile should be self-protection rather than punishment for the sake of punishment. We do not slay mad dogs to punish them for the crime of rabies, but simply to prevent ourselves and others from being bitten.

The idea is gradually gaining strength that the most just as well as the most effective means of protection from the moral imbecile is moral education. If there is injustice involved in the fact that he was created a moral imbecile, then this is the most direct and obvious means of righting that wrong; if there is no such injustice, it still remains the best possible policy, both as regards society and the subject himself.

And, happily, of the three sets of brain areas, that which forms the physical basis of the moral faculties is by far the most capable of improvement by cultivation. It is the part which most quickly and fully responds to educative influences. And there is entire correspondence in the improved outward conduct, which may as truly be looked upon as the effect of increased brain-power as stronger muscular action is of more highly developed muscles.

History demonstrates the pre-eminent educability of the moral part of man. The ancient athlete did not differ essentially from his modern ectype. There is not much to choose intellectually between Cicero and Wendell Phillips, between Aristotle and Herbert Spencer, between Copernicus and Charles Darwin, between the prehistoric genius who first smelted iron ore and Edison. The intellectual status of the educated classes of ancient Rome did not differ materially from that of the corresponding classes of modern London or New York; but compare their moral status! The wealth, beauty, and fashion of Rome assembled in eager thousands to witness the entertaining spectacle of wholesale human butchery: we stigmatize a bull-fight as intolerable savagery, worthy only of belated Spain, Portugal, or Mexico, and even the blood and bruises of a prize-fight are too much for the humanity and self-respect of any but blacklegs, thieves, "sports," and of a few scions of royalty and other *quasi*-respectable men. The ancients punished not only their criminals but often their innocent captives with death by torture: imagine a populous city of our day, absorbed in its various employments and pleasures, unconcerned while in full sight on a neighboring plain men are for days together writhing and moaning out the inconceivable agonies of crucifixion! Not only would such a thing be impossible in our day, but we are actually divided in opinion as to whether painless death by electrocution is not too barbarous a way of disposing of criminals. The ancients immured their lunatics and idiots in noisome subterranean dungeons, and left their paupers, their halt, blind, and deaf to shift for themselves or to depend upon casual private benevolence: we build almshouses, hospitals, and asylums, and our best scientific skill is taxed to its utmost in behalf of our unfortunates of these classes.

Such are a few of the ways in which improvement in the average moral sentiment of humanity within the Christian era is shown. We wonder at the monstrous cruelties of past ages. How could they have been possible, we ask, since "human nature has always been the same"? But human nature has *not* always been the same; it has always been changing; it is changing now, and it will always continue to change. And the rate of improvement is continually accelerating. Those born since the war find

it difficult to comprehend the barbarities of even one short generation ago. Their children will find the barbarities of to-day equally incredible. The horrors of Siberia, of the Russian persecution of Israel, of the no less infamous sweat-shops in our own country, may relegate the latter third of the nineteenth century to the same limbo of infamy to which the ages of Nero and Simon Legree are condemned, notwithstanding the comparatively great ameliorations in the average condition of the human race. Still later generations will wonder at the possibility of inhumanity which in our day condemns the many to life-shortening and life-embittering toil that the few may consume in luxurious idleness the price of their sweat and suffering; at the travesty of justice which punishes the criminal who robs his one victim with his puny arm of flesh and bends the knee to the ruffian who despoils his thousands with his mightier brain; at the selfish greed of the titled idlers who partition the soil among themselves and take heavy toll of the multitude of Earth's children for presuming to live upon the bosom of their common mother; at the unspeakable cruelty of the sex which flatters and spoils with indulgence a portion of the other sex, and drives by its tyranny another portion to starvation, suicide, or infamy.

Thus the mists which becloud the moral perceptions of men and chill their nobler impulses will lift one after another, as generation succeeds generation. But not until the law of love shall have made civil laws with their penalties superfluous and obsolete, not until the universal enforcement of the golden rule, not by objective, but by subjective penalties, will the moral education of mankind be complete.

In his later work, on Leonardo da Vinci and the Alps, Prof. Gustavo Uzielli treats of certain passages in the great artist's manuscripts containing references to the Alps. Telling of his ascent of Monboso or Monte Rosa in the middle of July, Leonardo incidentally remarks that snow rarely falls on the summit, but only hail in the summer, when the clouds are highest; also, that the extreme darkness of the sky and the luminosity of the sun are accounted for by the less extent of atmosphere between the spectator and the sun than if he stood on the lower plains at the foot of the mountain. The fruits of Leonardo's observations of the Alps are to be found in his works as an artist, and particularly in his portrait of the Mona Lisa, whom he placed amid their snows. But he studied them also with a practical eye, with a view to the utilization of the water that flows down their sides to the plains of Lombardy. Operations in connection with this purpose required the personal examination of the formation of the mountains; and while on his excursions he studied their geology, the density of matter, the action of light, and the composition of the atmosphere. His attention was also occupied with botanical studies and observations of the flight of birds. And there is evidence that he looked at the mountains also with the eye of a military engineer.

THE AUSTRALIAN MARSUPIAL MOLE.

By Dr. E. TROUESSART.

THE discovery of a new mammal with distinct enough characteristics to constitute the type of a new family, possibly of an order, in the class of Didelphæ or Aplacentariæ, is, at this age, a zoölogical event of great importance. The discovery is still more interesting in the case of an animal presenting so curious a form and organization as the one about to be described. The account we give of it is taken from the original memoir of Mr. E. C. Stirling, Director of the South Australian Museum and professor in the University of Adelaide, who found the animal in the central desert of Australia. The researches of English naturalists, especially of the ornithologist Gould, have made us so well acquainted with the fauna of New Holland that the announcement of the existence in that country of a living mammal that fills what has long been recognized as a gap in it is a real surprise.

The *Notoryctes*, as Prof. Stirling has named it, is a marsupial mole presenting remarkable analogies at once with the *Chrysochlores*, or moles, of the Cape of Good Hope, placentary insectivores peculiar to South Africa, and with the primitive mammals of the Secondary period and the beginning of the Tertiary, of which only the dentition is known to us. The name, *Notoryctes typhlops*, means blind burrower of the South.

The first individual of this species, of which Prof. Stirling saw the remains in very bad condition, was captured in 1888 by Mr. Coulthard, a cattle-raiser of northern South Australia. Following the tracks of the animal, he found it at the foot of a tuft of porcupine-grass (*Spinifex* or *Triodia irritans*). Although he had lived many years in the country, he had never seen or heard of it before. The region where it was found is about a thousand miles north of Adelaide; is bounded on the northeast by the dry bed of Finke River, and is a country of dunes and red sand, with spots of vegetation composed exclusively of *Spinifex* and *Acacia*. It rarely rains there. The species does not seem to be very abundant, and the natives appeared to have no knowledge of the animal when a figure of it was shown them. Much interested in his discovery, Prof. Stirling visited the South Australian desert and procured six specimens of the Notoryctes, four female and two male, and preserved them in alcohol for dissection on his return to Adelaide.

It was only with the assistance of the natives, and their surprising gifts in following the tracks of an animal, that it was possible to procure the precious specimens. The rainy season of the short semitropical summer of the country is the most favorable time

for this kind of investigation. The tracks of the animal are then preserved in the ground, while the soil is at other times too friable to retain any mark. The Notoryctes is essentially a burrower, and never comes out from under the sand except to run a few feet in a slow and tortuous gait, dragging its belly along the ground. It walks, clinching the outer edges of its claws in the ground, leaving a triple, often interrupted, sinuous track, the lateral lines of which are drawn by the feet, the middle line by the tail, on which the animal supports itself by beating it on the ground. The track resembles those of some Australian lizards, which Prof. Stirling was apt at first to mistake for them.

The Notoryctes burrows obliquely in the sand, going two or three inches under the ground, and never betraying its passage except by a slight undulation of the soil. In digging it uses its conical nose, which is protected by a horny plate, and the strong, mattock-shaped claws of its fore feet. The hind feet, which are wider and spade-shaped, throw the sand back so that no trace is left of the tunnel which it hollows. It comes to the surface a few yards farther on, and then buries itself again, all without making any noise. It is prodigiously agile and swift, a property on which Mr. Benham, who lived for some time at Idracowra, says: "Everybody here can tell you how soon one of these animals will get away by digging in the sand. I had brought a live one to the house and we were talking of its agility in digging. Mr. Stokes desired to see it at work. After spading and turning over the ground near the house, we set the animal down; I held it in my hands till it was nearly hidden, and then tried to overtake it by scratching the ground behind it, but it was quicker than I. I took a shovel and tried to find it, but without success. Another man came to my help with a second shovel, and also a native woman used to digging in the ground with her hands. But all three of us could not find it."

The Notoryctes are hard to keep alive, even if large tubs full of sand are provided. Night and day can be heard the slight sound they make in digging in this friable soil. They would not touch the ants which Mr. Stirling gave them, although ants were found in their stomachs. On the other hand, they readily ate the large white grubs of long-horned beetles and Lepidoptera; one of them even ate bread, but it died the next day. They did not try to bite when taken in the hand. The natives call them *oor-quamata*, and seem to have a superstitious fear of them, arising perhaps from the animal's being almost unknown. They have never seen the young ones. The intestines of different individuals dissected by Mr. Stirling contained ants and other insects.

At first sight, the animal looks very much like the *Chrysochlores*, or golden moles of the Cape, but differs from them by

its strong tail (the Chrysochlores have none), in the shape of its incisors, and in the presence of a pouch in the female. It is smaller than the European mole. Its pelage is yellowish, golden at some points, and silvered at others. It has no distinct neck, but the cheeks merge into the shouders. It results that the body

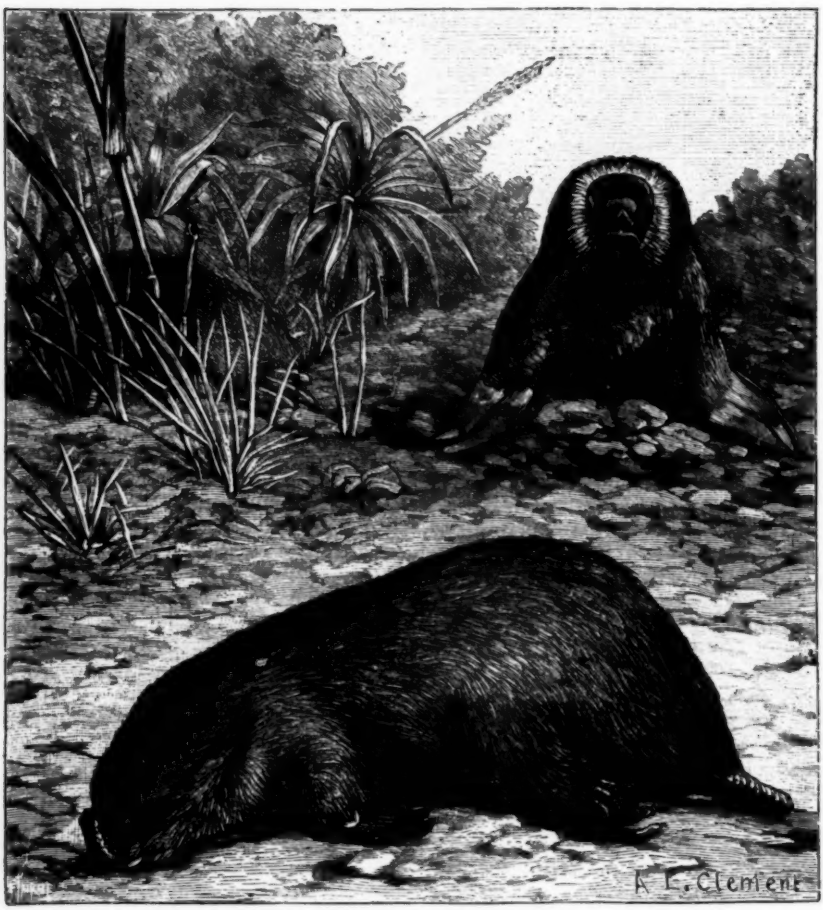

FIG. 1.—THE NEW MAMMAL, NOTORYCTES TYPHLOPS (slightly reduced).

is strongly arched. The nose, the feet, and the tail only are in the same plane. The nostrils are pierced through the horny plate which protects the muzzle, and which is divided in two by a transversal furrow. The mouth is underneath. The tongue is broad and shaped like a man's tongue.

There are no outside traces of eyes. Those organs are not even indicated by a pigmentary spot visible under the skin. The external ear is represented by a small roundish hole. The tail is singular, having the form of a truncated cone; is bare, ringed,

hidden to a considerable extent by the hairs of the back, but fully visible from below. It is swelled out near the middle by two considerable lateral tuberosities. The fore feet are similar to those of the Chrysochlores. The two large arched and compressed nails of the third and fourth digits conceal the others, with the exception of the obtuse and corneous nail of the fifth digit, which is turned back and inserted at the base of the fourth. On examining the narrow palm of this paw, we can discover the thin, atrophied nails of the thumb and second finger. The palm is cleft, and the fingers form two groups: the outer, consisting of the third, fourth, and fifth; and the inner, of the first and second. The hind paws are likewise short and very thick, more robust than those of the Chrysochlores, spade-shaped, have the sole turned outward, are deeply grooved, and bare to the metatarsus.* The first four toes are subequal; the fifth is represented by a short nail, much like that of the hand, and flanked by a large, broad, and flat sesamoid bone. The tibia is thick.

The dentition of the Notoryctes comprises forty teeth—ten in each branch of the jaws. The molars resemble those of the Chry-

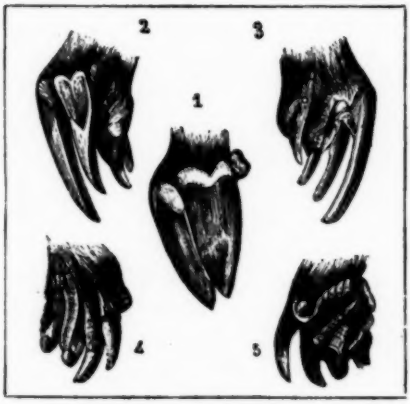

FIG. 2.—FEET OF THE NOTORYCTES. 1, 2, and 3, fore foot seen in front, in profile, and from beneath; 4 and 5, hind foot, from above and from beneath.

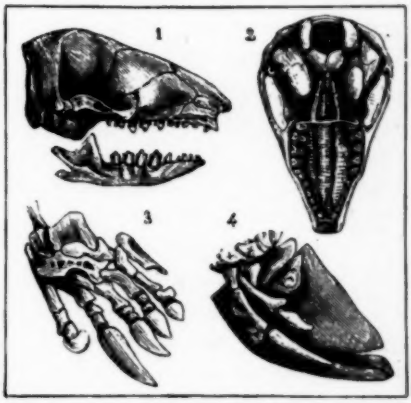

FIG. 3.—DETAILS OF THE SKELETON (enlarged). 1 and 2, skull, profile and from beneath; 3 and 4, feet.

sochlores, having, like them, V-formed crowns; but the front teeth, especially the incisors, are much smaller than those of the Chrysochlores. This fact is remarkable, considering that the general form of the skull is also strikingly like that of the Chrysochlores. The median incisors are, like those of the *Musaraignes* and most of the placentary insectivores, *scalpriformed*, or thick and hooked like the teeth of rodents, and constitute strong organs of prehension which touch on the median line. On the other

* From an examination of the osteology, we should say that the hind feet of the Notoryctes are similar in form to the fore feet of the real moles.

hand, the front teeth of the Notoryctes are small, hardly more than pegs, and leave a considerable gap on the median line, a disposition like that observed in some of the edentates. It might be well to compare this dentition with that of the *Myrmecobia*, which is also Australian, and with that of some of the types of Eocene fossil mammals which have recently been discovered in

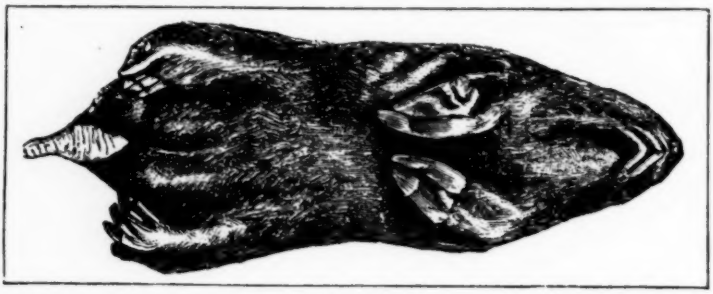

FIG. 4.—NOTORYCTES. (View of the under side; two thirds the natural size.)

South America. The angular apophysis of the lower jaw is markedly bent within, a tolerably constant characteristic of the opossums. The marsupial bones, on the other hand, are but little developed. They are represented only by two small osseous nodules diverging forward and united in the tendon of the oblique external muscle of the abdomen at its insertion on the symphysis of the pubis. They are hardly visible with the lens, and might easily pass undetected in a hasty or superficial dissection. Nothing is yet known of the method of reproduction of the Notoryctes.

As a whole, we are struck by the resemblances exhibited between the Notoryctes and the African Chrysochlores; the forms of the skull, of the molar teeth, and of the fore limb are such as to lead us to suppose something more than a simple secondary adaptation depending on an identical mode of life. The unlikeness, on the contrary, between the incisors and the canine teeth of the two types is deserving of closer study. It is of interest to recollect that these two genera are not the only ones which establish by their outer forms a bond of relationship between the South African and the Australian fauna. The *Pedetes* (*Helamy*), or great jerboa of the Cape, exhibits absolutely the forms of the Australian kangaroos, although it is a placentary rodent. There are also well-known relations between the South African and the Australian flora.—*Translated for The Popular Science Monthly from La Nature.*

[Mr. J. Douglas Ogilby has reached the conclusion, after a careful study of Mr. Stirling's accounts of this animal, that in it we have at last obtained a definite connecting link between the Monotremes (*Ornithorhyncus*) and the Marsupials (kangaroos and opossums). At the present state of our knowledge it would, he thinks, be presumptuous to class Notoryctes among the Monotremes proper, although several naturalists incline to the opinion that its affinities are closer to those animals than to the Marsupials.—ED. P. S. M.]

JUSTUS VON LIEBIG:

AN AUTOBIOGRAPHICAL SKETCH.*

MY father, who had a color warehouse, frequently occupied himself in making some of the colors in which he dealt, and for that purpose had fitted up for himself a small laboratory to which I had access, and where I sometimes enjoyed the privilege of helping him. He made his experiments as prescribed in works upon chemistry, which were, with great liberality, lent to the inhabitants of Darmstadt from the rich Court Library.

The lively interest which I took in my father's labors naturally led me to read the books which guided him in his experiments, and such a passion for these books was gradually developed in me that I became indifferent to every other thing that ordinarily attracts children. Since I did not fail to fetch the books from the Court Library myself, I became acquainted with the librarian Hess, who occupied himself successfully with botany, and as he took a fancy to the little fellow, I got, through him, all the books I could desire for my own use. Of course, the reading of books went on without any system. I read the books just as they stood upon the shelves, whether from below upward or from right to left was all the same to me; my fourteen-year-old head was like an ostrich stomach for their contents, and among them I found side by side upon the shelves the thirty-two volumes of Macquer's

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* Read at a joint meeting of societies in the Chemical Laboratories, University College, Liverpool, on Wednesday evening, March 18, 1891, by Prof. J. Campbell Brown, D. Sc.

[At the recent celebration of the Jubilee of the Chemical Society, reference was made to the wonderful energy and ability of Liebig, to the great work which he did in founding organic chemistry, and to the immense stimulus which he gave, alike in his own country and in England, to scientific investigation in pure chemistry and in its applications to agriculture, physiology, and pathology.

Very opportunely a portion of an autobiographical sketch in Liebig's own handwriting has just come to light, in which he gives a most interesting account of the formation of his habits of thought, and of the development of his scientific activity. He also gives an amusing description of the lectures given in his student days by professors of the deductive method.

In his sixtieth year, we are told, Liebig wrote some biographical sketches which were laid aside and could not be found when he wished to resume them. They were never finished. A portion of the manuscript was found among some other papers in Liebig's handwriting by his son Dr. Georg Baron von Liebig, and has been published by the latter in the *Deutsche Rundschau* for January, 1891. Mr. E. K. Muspratt has been good enough to lend me a copy which he received from his friend the present baron.

I have endeavored to render it into English as literally as the difference in the idiom and modes of expression in the two languages will permit; and it is now made public in England by the kind permission of the *Deutsche Rundschau*.

His method of teaching and its remarkable success are worthy of attention at the present time, when technical education is occupying so much of the public mind.]

Chemical Dictionary, Basil Valentine's Triumphal Car of Antimony, Stahl's Phlogistic Chemistry—thousands of essays and treatises in Göttling's and Gehlen's periodicals, the works of Kirwan, Cavendish, etc.

I am quite sure that this manner of reading was of no particular use so far as acquisition of exact knowledge is concerned, but it developed in me the faculty, which is peculiar to chemists more than to other natural philosophers, of thinking in terms of phenomena; it is not very easy to give a clear idea of phenomena to any one who can not recall in his imagination a mental picture of what he sees and hears, like the poet and artist for example. Most closely akin is the peculiar power of the musician, who, while composing, thinks in tones which are as much connected by laws as the logically arranged conceptions in a conclusion or series of conclusions. There is in the chemist a form of thought by which all ideas become visible to the mind as the strains of an imagined piece of music. This form of thought is developed in Faraday in the highest degree, whence it arises that to one who is not acquainted with this method of thinking, his scientific works seem barren and dry, and merely a series of researches strung together, while his oral discourse, when he teaches or explains, is intellectual, elegant, and of wonderful clearness.

The faculty of thinking in phenomena can only be cultivated if the mind is constantly trained, and this was effected in my case by my endeavoring to perform, so far as my means would allow me, all the experiments whose description I read in the books. These means were very limited, and hence it arose that, in order to satisfy my inclination, I repeated such experiments as I was able to make a countless number of times, until I ceased to see anything new in the process, or till I knew thoroughly every aspect of the phenomenon which presented itself. The natural consequence of this was the development of a memory of the sense, that is to say of the sight, a clear perception of the resemblances or differences of things or of phenomena, which afterward stood me in good stead.

One will easily understand this if one imagines, for instance, a white or colored precipitate which is produced by mixing two liquids; it is formed either at once or after some time, it is cloudy or of a curdy or gelatinous character, sandy or crystalline, dull or bright, it deposits easily or slowly, etc.; or if it is colored it has a certain tint. Among the countless white precipitates each has something peculiar to itself; and when one has experience in this sort of appearances, whatever one sees during an investigation at once awakens the remembrance of what one has seen. The following example will make clear what I mean by sight or eye memory: During our joint research on uric acid, Wöhler one

day sent me a crystalline body which he had obtained by the action of peroxide of lead upon this acid: I immediately thereupon wrote to him with great joy, and without having analyzed the body, that it was allantoin. Seven years before I had had this body in my hands; it had been sent to me by C. Gmelin for investigation, and I had published an analysis of it in Poggendorf's *Annalen;* since that time I had not seen it again. But when we had analyzed the substance obtained from uric acid there appeared a difference in the amount of carbon, the new body gave one and a half per cent carbon less, and since the nitrogen had been determined by the qualitative method a corresponding quantity (four per cent) of nitrogen more; consequently it could not possibly be allantoin. However, I trusted my eye-memory more than my analysis, and was quite sure that it was allantoin, and the thing now to be done was to find the remains of the substance previously analyzed in order to analyze it afresh. I could describe the little glass in which it was with such precision that my assistant at last succeeded in picking it out from among a couple of thousand other preparations. It looked exactly like our new body, except that examination under the lens showed that Gmelin, in the preparation of his allantoin, had purified it with animal charcoal, some of which having passed through the paper in the filtration had become mixed with the crystals.

Without the complete conviction which I had that the two bodies were identical, the allantoin produced artificially from uric acid would undoubtedly have been regarded as a new body, and would have been designated by a new name, and one of the most interesting relations of uric acid to one of the constituents of the urine of the fœtus of the cow would perhaps have remained for a long time unobserved. In this manner it came to pass that everything I saw remained intentionally or unintentionally fixed in my memory with equal photographic fidelity. At a neighboring soap-boiler's I saw the process of boiling soap, and learned what "curd soap" and "fitting" are, and how white soap is made; and I had no little pleasure when I succeeded in showing a piece of soap of my own making, perfumed with oil of turpentine. In the workshop of the tanner and dyer, the smith and brass-founder, I was at home, and ready to do any hand's turn.

In the market at Darmstadt I watched how a peripatetic dealer in odds and ends made fulminating silver for his pea-crackers. I observed the red vapors which were formed when he dissolved his silver, and that he added to it nitric acid, and then a liquid which smelt of brandy, and with which he cleaned dirty coat-collars for the people. With this bent of mind it is easy to understand that my position at school was very deplorable; I had no ear-memory and retained nothing or very little of what is learned through this

sense; I found myself in the most uncomfortable position in which a boy could possibly be; languages and everything that is acquired by their means, that gains praise and honor in the school, were out of my reach; and when the venerable rector of the gymnasium (Zimmermann), on one occasion of his examination of my class, came to me and made a most cutting remonstrance with me for my want of diligence, how I was the plague of my teachers and the sorrow of my parents, and what did I think was to become of me, and when I answered him that I would be a chemist, the whole school and the good old man himself broke into an uncontrollable fit of laughter, for no one at the time had any idea that chemistry was a thing that could be studied.

Since the ordinary career of a gymnasium student was not open to me, my father took me to an apothecary at Heppenheim in the Hessian Bergstrasse; but at the end of ten months he was so tired of me that he sent me home again to my father. I wished to be a chemist, but not a druggist. The ten months sufficed to make me completely acquainted alike with the use and the manifold applications of the thousand and one different things which are found in a druggist's shop.

Left to myself in this way, without advice and direction, I completed my sixteenth year, and my persistent importunity at last induced my father to give me permission to go to the University of Bonn; whence I followed to Erlangen the Professor of Chemistry, Kastner, who had been called to the Bavarian University. There arose at that time at the newly established University of Bonn an extraordinary quickening of scientific life; but the degenerate philosophical methods of investigation, as they had been embodied in Oken, and still worse in Wilbrand, had a most pernicious influence on the branches of natural science, for it had led alike in lecture and in study to a want of appreciation of experiment and of an unprejudiced observation of Nature, which was ruinous to many talented young men.

From the professional chair the pupil received an abundance of ingenious contemplations; but, bodiless as they were, nothing could be made of them. The lectures of Kastner, who was considered a most eminent chemist, were without order, illogical, and arranged just like the jumble of knowledge which I carried about in my head. The relations which he discovered between phenomena were somewhat after the following pattern:

"The influence of the moon upon the rain is clear, for as soon as the moon is visible the thunderstorm ceases," or "the influence of the sun's rays on water is shown by the rise of the water in the shafts of mines, some of which can not be worked in the height of summer." That we see the moon when the thunderstorm is dispelled, and that the water rises in the mine when the brooks

which drive the pumps dry up in summer, was, of course, too blunt an explanation for a clever lecture.

It was then a very wretched time for chemistry in Germany. At most of the universities there was no special chair for chemistry; it was generally handed over to the professor of medicine, who taught it, as much as he knew of it, and that was little enough, along with the branches of toxicology, pharmacology, materia medica, practical medicine, and pharmacy. Many years after this in Giessen, descriptive and comparative anatomy, physiology, zoölogy, natural history, and botany were in one single hand.

While the labors of the great Swedish chemist, the English and French natural philosophers, Humphry Davy, Wollaston, Biot, Arago, Fresnel, Thenard, and Dulong, opened up entirely new spheres of investigation, all these inestimable acquisitions found no soil in Germany where they could bear fruit. Long years of war had undermined the well-being of the people, and external political pressure had brought in its train the desolation of our universities, filled men with painful anxiety for many years, and turned their desires and their strength in other directions. The national spirit had asserted its freedom and independence in ideal spheres, and by the destruction of belief in authority had brought rich blessings in many ways—for example, in medicine and philosophy; only in physiology it had broken through its natural limits, and wandered far beyond experience.

The goal of science and the fact that it has value only when it is useful to life had almost dropped out of sight, and men amused themselves in an ideal world which had no connection with the real one. It was considered an almost debasing sentiment, and one unworthy of an educated person, to believe that in the body of a living being the crude and vulgar inorganic forces played any part. Life and all its manifestations and conditions were perfectly clear. Natural phenomena were clothed in bewitchingly lovely dress, cut out and fitted by clever men, and this was called philosophical investigation. Experimental instruction in chemistry was all but extinct at the universities, and only the highly educated pharmacists, Klaproth, Hermbstädt, Valentin Rose, Trommsdorff, and Buchholz, had themselves preserved it, but in another department.

I remember, at a much later period, Prof. Wurzer, who held the chair of chemistry at Marburg, showing me a wooden table drawer, which had the property of producing quicksilver every three months. He possessed an apparatus which mainly consisted of a long clay pipe-stem, with which he converted oxygen into nitrogen by making the porous pipe-stem red hot in charcoal, and passing oxygen through it.

Chemical laboratories, in which instruction in chemical anal-

ysis was imparted, existed nowhere at that time. What passed by that name were more like kitchens filled with all sorts of furnaces and utensils for the carrying out of metallurgical or pharmaceutical processes. No one really understood how to teach it. I afterward followed Kastner to Erlangen, where he had promised to analyze some minerals with me; but unfortunately he did not himself know how to do it, and he never carried out a single analysis with me.

The benefit which I gained through intercourse with other students during my sojourn in Bonn and Erlangen was the discovery of my ignorance in very many subjects which they brought with them from school to the university, and since I got nothing to do in chemistry I laid out all my energies to make up for my previously neglected school studies. In Bonn and Erlangen small numbers of students joined with me in a chemico-physical union, in which every member in turn had to read a paper on the question of the day, which, of course, consisted merely in a report on the subjects of the essays which appeared monthly in Gilbert and Schweigger's *Journal.*

In Erlangen, Schelling's lectures attracted me for a time, but Schelling possessed no thorough knowledge in the province of natural science, and the dressing up of natural phenomena with analogies and in images, which was called exposition, did not suit me. I returned to Darmstadt fully persuaded that I could not attain my ends in Germany.

The dissertations of Berzelius—that is to say, the better translation of his handbook, which had a large circulation at that time—were as springs in the desert. Mitscherlich, H. Rose, Wöhler, and Magnus had then repaired to Berzelius, in Stockholm; but Paris offered me means of instruction in many other branches of natural science, as, for instance, physics, such as could be found united in no other place. I made up my mind to go to Paris. I was then seventeen and a half years old. My journey to Paris, the way and manner in which I came in contact with Thenard, Humboldt, Dulong, and with Gay-Lussac, and how the boy found favor in the sight of those men, borders on the fabulous, and would be out of place here. Since then it has frequently been my experience that marked talent awakens in all men, I believe I may say without exception, an irrepressible desire to bring about its development. Each helps in his own way, and all together as if they were acting in concert; but talent only compels success if it is united with a firm, indomitable will. External hindrances to its development are in most cases very much less than those which lie in men themselves; for just as no one of the forces of Nature, however mighty it may be, ever produces an effect by itself alone, but always only in conjunction with other forces; so

a man can only make valuable that which he learns without trouble, or acquires readily, for which, as we say, he has a natural gift, if he learns many other things in addition, which perhaps cost him more trouble to acquire than other people.

Lessing says that talent really is *will and work*, and I am very much inclined to agree with him.

The lectures of Gay-Lussac, Thenard, Dulong, etc., in the Sorbonne, had for me an indescribable charm; the introduction of astronomical or mathematical method into chemistry, which changes every problem when possible into an equation, and assumes in every uniform sequence of two phenomena a quite certain connection of cause and effect, which, after it has been searched for and discovered, is called "explanation" or "theory," had led the French chemists and physicists to their great discoveries. This kind of "theory" or "explanation" was as good as unknown in Germany, for by these expressions was understood not something "experienced," but always something which man must add on and which he fabricates.

French exposition has, through the genius of the language, a logical clearness in the treatment of scientific subjects very difficult of attainment in other languages, whereby Thenard and Gay-Lussac acquired a mastery in experimental demonstration. The lecture consisted of a judiciously arranged succession of phenomena—that is to say, of experiments whose connection was completed by oral explanations. The experiments were a real delight to me, for they spoke to me in a language I understood, and they united with the lecture in giving definite connection to the mass of shapeless facts which lay mixed up in my head without order or arrangement. The antiphlogistic or French chemistry had, it is true, brought the history of chemistry before Lavoisier to the guillotine; but one observed that the knife only fell on the shadow, and I was much more familiar with the phlogistic writings of Cavendish, Watt, Priestley, Kirwan, Black, Scheele, and Bergmann, than with the antiphlogistic; and what was represented in the Paris lectures as new and original facts appeared to me to be in the closest relation to previous facts, so much so, indeed, that when the latter were imagined away the others could not be.

I recognized, or more correctly perhaps the consciousness dawned upon me, that a connection in accordance with fixed laws exists not only between two or three, but between all chemical phenomena in the mineral, vegetable, and animal kingdoms; that no one stands alone, but each being always linked with another, and this again with another, and so on, all are connected with each other, and that the genesis and disappearance of things is an undulatory motion in an orbit.

What impressed me most in the French lectures was their

intrinsic truth, and the careful avoidance of all pretense in the explanations; it was the most complete contrast to the German lectures, in which the whole scientific teaching had lost its solid construction through the preponderance of the deductive method.

An accidental occurrence drew A. von Humboldt's attention to me in Paris, and the interest which he took in me induced Gay-Lussac to complete, in conjunction with me, a piece of work which I had begun. In this manner I had the good fortune to enjoy the closest intercourse with the great natural philosopher; he worked with me as he had formerly worked with Thenard; and I can well say that the foundation of all my later work and of my whole course was laid in his laboratory in the arsenal.

I returned to Germany, where through the school of Berzelius, H. Rose, Mitscherlich, Magnus, and Wöhler, a great revolution in inorganic chemistry had already commenced. Through the support of von Humboldt's warm recommendation, an extraordinary professorship of chemistry at Giessen was conferred upon me in my twenty-first year.

My career in Giessen commenced in May, 1824. I always recall with pleasure the twenty-eight years which I spent there: it was as if Providence had led me to the little university. At a larger university or in a larger place my energies would have been divided and dissipated, and it would have been much more difficult, and perhaps impossible, to reach the goal at which I aimed; but at Giessen everything was concentrated in work, and in this I took passionate pleasure. The need for an institution in which the students could be instructed in the art of chemistry, by which I mean familiarity with chemical analytical operations, and skill in the use of apparatus, was then being felt; and hence it happened that, on the opening of my laboratory for teaching analytical chemistry and the methods of chemical research, students by degrees streamed to it from all sides. As the numbers increased I had the greatest difficulty with the practical teaching itself. In order to teach a large number at one time it was necessary to have a systematic plan, or step-by-step method, which had first to be thought out and put to the proof. The manuals which several of my pupils have published later (Fresenius and Will) contain essentially, with little deviation, the course which was followed at Giessen; it is now familiar in almost every laboratory.

The production of chemical preparations was an object to which I paid very particular attention; it is very much more important than is usually believed, and one can more frequently find men who can make very good analyses than such as are in a position to produce a pure preparation in the most judicious way. The formation of a preparation is an art, and at the same time a

qualitative analysis, and there is no other way of making one's self acquainted with the various chemical properties of a body than by first producing it out of the raw material, and then converting it into its numerous compounds and so becoming acquainted with them.

By ordinary analysis one does not learn by experience what an important means of separation crystallization is in skillful hands; and just as little the value of an acquaintance with the peculiarities of different solvents. Consider only an extract of a plant or of flesh which contains half a dozen crystalline bodies in very small quantities imbedded in extraneous matter, which almost entirely masks the properties of the others; and yet, in this magma, we can recognize by means of chemical reactions the peculiarities of every single body in the mixed mass, and learn to distinguish what is a product of decomposition and what is not, in order to be able to separate them afterward by means which will exert no decomposing influence. An example of the great difficulty of finding the right way in such researches is afforded by the analysis of bile by Berzelius. Of all the numerous substances which he has described as its constituents no one is, properly speaking, contained in the natural bile.

An extremely short time had been sufficient for the famous pupils of the Swedish master to give a wonderful degree of perfection to mineral analysis, which depends on an accurate knowledge of the properties of inorganic bodies; their compounds and their behavior to each other were studied in all directions by the Swedish school with a keenness quite unusual previously and even now unsurpassed. Physical chemistry, which investigates the uniform relations between physical properties and chemical composition, had already gained a firm foundation by the discoveries of Gay-Lussac and von Humboldt on the combining proportions of bodies in the gaseous state, and those of Mitscherlich on the relations between crystalline form and chemical composition; and in chemical proportions the structure appeared to have received its coping-stones and to stand forth completed. All that foreign countries had acquired in by-gone times in the way of discoveries now yielded rich fruit also in Germany.

Organic chemistry—or what is now called organic chemistry—had then no existence. It is true that Thenard and Gay-Lussac, Berzelius, Prout, and Döbereiner, had already laid the foundations of organic analysis, but even the great investigations of Chevreul upon the fatty bodies excited but little attention for many years. Inorganic chemistry demanded too much attention, and, in fact, monopolized the best energies.

The bent which I acquired in Paris was in a quite different direction. Through the work which Gay-Lussac had done with

me upon fulminating silver I was familiar with organic analysis, and I very soon saw that all progress in organic chemistry depended essentially upon its simplification; for in this branch of chemistry one has to do not with different elements which can be recognized by their peculiar properties, but always with the same elements whose relative proportions and arrangement determine the properties of organic compounds. In organic chemistry an analysis is necessary to do that for which a reaction suffices in inorganic chemistry. The first years of my career in Giessen I devoted almost exclusively to the improvement of the methods of organic analysis, and the immediate result was that there began at this little university an activity which had never before been seen.

For the solution of innumerable questions connected with plants and animals, on their constituents, and on the reactions accompanying their transformation in the organism, a kindly fate brought together the most talented young men from all the countries of Europe, and any one can imagine what an abundance of facts and experiences I gained from so many thousands of experiments and analyses, which were carried out every year, and for so many years, by twenty and more indefatigable and skilled young chemists.

Actual teaching in the laboratory, of which practiced assistants took charge, was only for the beginners; the progress of my special students depended on themselves. I gave the task and supervised the carrying out of it; as the radii of a circle have all their common center. There was no actual instruction; I received from each individual every morning a report upon what he had done on the previous day, as well as his views on what he was engaged upon. I approved or made my criticisms. Every one was obliged to follow his own course. In the association and constant intercourse with each other, and by each participating in the work of all, every one learned from the others. Twice a week, in winter, I gave a sort of review of the most important questions of the day; it was mainly a report on my own and their work combined with the researches of other chemists.

We worked from break of day till nightfall. Dissipations and amusements were not to be had at Giessen. The only complaint, which was continually repeated, was that of the attendant (Aubel), who could not get the workers out of the laboratory in the evening, when he wanted to clean it. The remembrance of this sojourn at Giessen awakened in most of my pupils, as I have frequently heard, an agreeable sense of satisfaction for well-spent time.

I had the great good fortune, from the commencement of my career at Giessen, to gain a friend of similar tastes and similar aims, with whom, after so many years, I am still knit in the bonds

of warmest affection. While in me the predominating inclination was to seek out the points of resemblance in the behavior of bodies or their compounds, he possessed an unparalleled faculty of perceiving their differences. A keenness of observation was combined in him with an artistic dexterity, and an ingeniousness in discovering new means and methods of research or analysis such as few men possess. The achievement of our joint work upon uric acid and oil of bitter almonds has frequently been praised; it was his work. I can not sufficiently highly estimate the advantage which the association with Wöhler brought to me in the attainment of my own as well as our mutual aims, for by that association were united the peculiarities of two schools—the good that was in each became effective by co-operation. Without envy and without jealousy, hand in hand, we pursued our way; when the one needed help the other was ready. Some idea of this relationship will be obtained if I mention that many of our smaller pieces of work which bear our joint names were done by one alone; they were charming little gifts which one presented to the other.

After sixteen years of the most laborious activity I collected the results gained, so far as they related to plants and animals, in my Chemistry applied to Agriculture and Physiology, two years later in my Animal Chemistry, and the researches made in other directions in my Chemical Letters. The last-mentioned was generally received as a popular work, which, to those who study it more closely, it really is not, or was not at the time when it appeared. Mistakes were made, not in the facts, but in the deductions about organic reactions; we were the first pioneers in unknown regions, and the difficulties in the way of keeping on the right path were sometimes insuperable. Now, when the paths of research are beaten roads, it is a much easier matter; but all the wonderful discoveries which recent times have brought forth were then our own dreams, whose realization we surely and without doubt anticipated.

Here the manuscript ends, and it is to be hoped that more of it will yet be found.

Liebig's reference to Wöhler is very touching, and shows a side of his character which all his pupils knew well; they tell many genial stories illustrating his unselfishness and kindness of heart. One could have wished that he had not considered the stories "bordering on the fabulous," of how he "found favor in the sight of Humboldt, Gay-Lussac, and Thenard, out of place here." They would have been far from out of place. Mr. Muspratt supplies one of these stories as he heard it from Liebig's own lips, in the Munich Laboratory, as follows:

Liebig frequently spoke in most grateful terms of the kind manner in which he—a youth barely eighteen—was received by Gay-Lussac, Thenard, and other eminent chemists, in Paris.

In the summer of 1823 he gave an account of his analysis of fulminating silver before the Academy. Having finished his paper, as he was packing up his preparations, a gentleman came up to him and questioned him as to his studies and future plans, and, after a most exacting examination, ended by asking him to dinner on the following Sunday. Liebig accepted the invitation, but, through nervousness and confusion, forgot to ask the name and address of his interviewer. Sunday came, and poor Liebig was in despair at not being able to keep his engagement.

The next day a friend came to him and said, "What on earth did you mean by not coming to dine with von Humboldt yesterday, who had invited Gay-Lussac and other chemists to meet you?" "I was thunderstruck," said Liebig, "and rushed off, as fast as I could run, to von Humboldt's lodgings, and made the best excuses I could." The great traveler, satisfied with the explanation, told him it was unfortunate, as he had several members of the Academy at his house to meet him, but thought he could make it all right if he would come to dinner next Sunday. He went, and there made the acquaintance of Gay-Lussac, who was so struck with the genius and enthusiasm of the youth that he took him into his private laboratory, and continued, in conjunction with him, the investigation of the fulminating compounds.—*Chemical News.*

THE COTTON INDUSTRY IN BRAZIL.

By JOHN C. BRANNER, Ph. D.,
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COTTON is indigenous to Brazil. The oldest documents relating to that country contain many references to its existence there and to the uses made of it by the Indians at the time of the discovery. There is no indication, however, that it was then cultivated to any considerable extent by the natives. The picture of the indifference of the aborigines in regard to such matters is vividly suggested by the manner in which a few straggling plants are allowed to grow, even nowadays, about the houses of the civilized Indians, and by the poor classes generally throughout the interior of the country.

As soon, however, as the Portuguese came to Brazil, bringing with them a knowledge of the cultivation of cotton and of its uses, there was established an industry which has been an important factor in the material prosperity and development of the country. Although by the end of the seventeenth century cotton was quite generally cultivated throughout Brazil, it was used almost exclusively for domestic purposes until the last half of the

eighteenth century. The earliest record of its exportation is given incidentally in the story of the shipwreck of Jorge de Albuquerque Coelho, who sailed from Pernambuco in May, 1565. The passage was a stormy one, and the sea became so rough at one time that they were obliged to throw part of their cargo overboard. "And seeing that all this was of no avail, and that the waves grew the higher, as if they wished to overwhelm us, we threw overboard the artillery and many boxes of sugar, and many bales of cotton."

EARLY USES.—In early times—indeed, as late as 1747—cotton thread and cotton cloth were used throughout Brazil in lieu of money. In 1670 it was complained that, unless the exportation of cotton cloth was prohibited, "not a yard of cloth, or rather no money, would be found in Maranhão." Balls of cotton thread were used as small change, and circulated as such in all the shops and in all kinds of financial transactions. The manufacturers of these balls do not appear to have been always scrupulously honest, for the Legislature was finally obliged to take action to prevent the fraud of putting pieces of cloth, rags, and other such things in them. The trade in cotton between the neighboring captaincies became so large that the authorities of Maranhão, in order to keep all the money at home, prohibited the exportation of cotton from that place, and it was not until fifty years later (1756) that this law was repealed.

The manufacture of cotton cloth was carried on to such an extent ("the people generally, even the senators, were accustomed to dress in clothing made of cotton") that complaint was made to the King of Portugal by the Portuguese merchants that it was interfering with their export trade with the colony and with the receipts of the royal treasury. Instructions were, therefore, given (January 5, 1785) to the agents of the crown in Rio de Janeiro to prohibit all spinning-factories, and, if necessary, to confiscate the looms. This prohibition, however, did not extend to the factories and looms for making coarse cotton cloth, such as was used for clothing slaves and for like purposes.

Yet in the face of these obstacles cotton culture in Brazil rapidly increased. The only statistics to be obtained of the exportation of cotton up to the end of the eighteenth century are those of the captaincy or province of Maranhão. In 1760 Maranhão exported 24,960 pounds of cotton; and in 1800, 5,529,408 pounds. That captaincy, however, stood only second among those exporting cotton; Pernambuco exported more than twice as much as Maranhão, while Bahia, Rio de Janeiro, and Pará together exported about as much as Maranhão. Cotton was also one of the principal products of Rio Negro, Piauhy, Rio Grande do Norte, Parahyba, Alagôas, and Sergipe. These facts give us an idea of

the extent of cotton culture in Brazil at the end of the eighteenth century.

When, at the beginning of the nineteenth century, the royal family of Portugal came to Brazil, it ceased to be a mere colony; the empire was established, and a new impetus was given to all industries. The ports were made free to friendly foreign powers, and the decree prohibiting the use of looms was revoked.

THE COTTON REGION.—The territory in Brazil capable of yielding cotton is coextensive with the country itself. From São Paulo all along the coast to the Amazon, and, for that matter, throughout the entire country, cotton might be grown in almost unlimited quantities. In reality, however, it is only cultivated to any considerable extent in the drier regions of the north, and along the valley of the Rio São Francisco, and in some parts of the province of Minas Geraes.

In the north—i. e., to the north of Sergipe—a belt along the coast about fifty miles wide is, for the most part, devoted to the production of sugar. Immediately beyond this is the region in which cotton is actually grown, the width of which region depends almost solely upon the distance which the producers feel themselves able to transport it.

As cotton culture, replaced by the cultivation of sugar, has receded from the coast, the question of transportation has become a very serious one with Brazilian planters. Roads are usually so poor and markets so far away that the planters necessarily lose the greater part of their profits in the expense of transportation. The remedy generally recommended is railways; but railways, where they already exist, have not in all cases been found a remedy for this state of affairs. Cotton sent by rail from the interior of the province of São Paulo to the seaboard at Santos pays out in freight about thirteen per cent of its value. The planters of Pernambuco pay out from twenty-five to thirty per cent of the value of their cotton in freights. Along the large streams, where it is possible to ship cotton by water, it can be moved with some facility. As a rule, however, transportation is on horseback or muleback, and it is thus brought to market often for a distance of from three hundred to four hundred miles, trips sometimes requiring three or four months for a troop of mules, over roads that are nothing more than bridle-paths, and often very bad ones at that.

VARIETIES CULTIVATED.—It is not to be supposed that only native varieties of cotton are cultivated in Brazil. Indeed, the three varieties best known to and used by Brazilian planters are all exotic. The *crioulo* is a large bush from five to fifteen feet in height, is very hardy, and, if properly cared for, will last two or

three years. The smooth, black seeds of the *crioulo* * cling so firmly to each other that they separate only when pressed very strongly between the fingers, and the fiber can be stripped from them without their being separated and without leaving any lint upon them. The cotton, when ripe, clings firmly and compactly within the boll, and it is for this reason more difficult to pick.

The variety known as the *quebradinho* is distinguished from the preceding by having seeds which readily separate from each other. The seeds are fewer in number and the bolls smaller than in the *crioulo*. Both of these varieties, and the yellow variety mentioned below, are known as "tree cotton." One occasionally hears of tree cotton lasting from five to ten years; but, while this may be literally true, the crops borne by these old plants are hardly worth the picking.

The herbaceous variety (called *herbaceo*) is an annual plant, growing from three to five feet high, and is identical with that generally cultivated in the United States. The seeds separate in the bolls, and the ripe cotton hangs from them in large flocks. This species produces more fiber, sometimes from five to six times as much as either of the preceding kinds, but the quality is considered much inferior. The yield on a given piece of ground of the herbaceous cotton is four times as large as that of tree cotton, and in picking one can gather twice as much from the herbaceous in a given time. Herbaceous cotton is said to have been introduced from the United States, and there is no doubt about its having been taken to Brazil within a comparatively short period.

The only other variety deserving attention is the yellow or light brown, which, however, is not grown in any considerable quantities, owing undoubtedly to its color and to its small yield of fiber. The color is not generally considered an attractive one, but it is valued for certain household articles, such as hammocks, in which neutral tints and fast colors are desirable.

CULTIVATION.—Substantially the same system of cultivation is used to-day that was in vogue three hundred years ago. Auguste de Saint-Hilare wrote in 1812, "All the planter has to do is to burn off the woods and plant his seed at the proper season." This is the whole story. There is no uprooting of stumps, no digging out of sprouts, no breaking up with the plow, no preparation of the soil, no laying out of furrows, no cultivation other than the occasional chopping out with the hoe of weeds or sprouts.

Rotation of crops is almost entirely unknown. Fields are seldom laid out with any definite forms, as they would be if the

* This variety takes its name from the black color of the seeds, the word *crioulo* being sometimes applied to negroes in Brazil.

plow were in common use, but vary in shape to suit the convenience of the planters, who adapt themselves to the natural features of the surface and character of the soil. If the place to be planted is forest, whether heavy or of only a few years' growth, the laborers, with bill-hooks for the undergrowth and axes for the trees, begin clearing it from one side, felling the trees and undergrowth toward the open space, and leaving stumps of any height that may make the work of clearing easier. No effort is made to pile the brush in heaps. This work is done in the dry season, and the brush is allowed to lie for several months, until the approach of the rainy season, when the whole, being thoroughly dried by long exposure to the rays of a very hot sun, is set on fire. The want of arrangement of the branches permits the burning of all the leaves and of the small limbs, twigs, etc., but the larger branches and the trunks of the fallen trees are only blackened by the passing fire. A more desolate sight than one of these "new grounds" can not be imagined. Sometimes a few of the half-burned pieces are piled together and set on fire, but usually they are allowed to lie where they happen to have fallen. The soil is now ready for the seed. The laborers go over the field with large, heavy hoes, and with powerful blows open holes to receive the seeds at intervals more or less irregular. The cotton seeds are planted in these holes, and with the foot or hand covered with a little earth. The spaces between the hills are generally supposed to be from five to eight palms, according to the fertility of the soil. Sometimes rows are attempted in a rude, rambling way, and in such cases the hills are about six palms apart in one direction and eight in the other, according as the stumps and logs and half-consumed limbs may permit.

The planting season varies in different localities according to the time when the rains generally set in. Most of it is done in the months of February and March, though planting-time may vary a month or two either way, according to the season and the nature of the ground, low, rich soil generally being planted later than the dry uplands. Difference is also made with the kind of cotton, the tree cotton generally being planted a month or two earlier than the herbaceous. Sometimes other things are planted between the rows of cotton, such as beans, rice, or corn.

Shortly after the planting the season of rains sets in ,and cotton, weeds, sprouts, and all come up and grow with a vigor and rapidity only to be seen in the tropics. When the cotton is about to be choked out by useless vegetation, the hoes are sent to chop it out—an operation that is performed two or three times, or as often as circumstances are supposed to require it, during the year. The amount of cleaning required by a field depends upon the richness of the soil and upon the length and character of the win-

ter or wet season, rich soil and long, wet winters producing more weeds and requiring more attention. So far as tillage is concerned, this chopping out of the weeds and sprouts is the nearest approximation to cultivation the plants receive, and the soil naturally becomes as hard as a brick.

INSECTS.—While Brazil is the home of the cotton plant, it is at the same time the home of insects affecting that plant. Besides the "cotton-worm" (*Aletia argellacea*), which occurs in that country at times in vast swarms very much as it does in the Southern States, there are other moths whose larvæ attack the cotton in a similar manner. The "boll-worm" (*Heliothis armigera*) is also a native of Brazil, and occasionally does great injury to the cotton crop. But, while these insects exist in Brazil under climatic conditions more favorable to their multiplication than are those of the United States, these favorable circumstances are offset very materially by the vast number of insect enemies which these same climatic conditions foster. As a rule, the Brazilian planter feels himself utterly at the mercy of Fate when the "cotton-worms" attack his crop. No remedies for the evil are known, and none are ever attempted. They seem to think that to combat the plague would be to "fly in the face of Providence"; that when God wishes it stopped he'll send rains and stop it himself. The percentage of loss through these insects varies greatly, but I have known of many instances of a loss of fifty per cent of the crop. Such a loss, however, is unusually large for that country.

PICKING.—Cotton-picking does not assume the importance in Brazil that it does in the Southern United States. Fields are never large, and picking is done more at the leisure and convenience of the planter. With the varieties of tree cotton there is but little risk of loss in leaving the ripe cotton in the bolls longer than could be done with the herbaceous variety, for the seeds of the former, being more compact when they ripen, do not cause the fiber to thrust the mass in a loose flock from the boll, as is the case with the latter. The cotton-pickers carry baskets or bags with them, in which the cotton is placed as it is gathered, very much as is the custom in this country.

GINNING.—What kind of a gin to use has been a question of importance among Brazilian planters. The question was not between the various kinds of saw-gins, but between saw-gins and the old-fashioned way of cleaning cotton with two small wooden cylinders revolving close to each other.

The roller-gin is simply two short wooden cylinders, less than an inch in diameter, geared together and revolved close to each other after the fashion of a modern clothes-wringer. The raw cotton is fed slowly between the cylinders, and the seeds are removed by being pinched from the cotton and thrust back on the side from

which it is fed. This machine is objectionable on account of the slowness with which it operates, and also on account of its often crushing the seeds and thus soiling the staple.

The saw-gin was introduced into Brazil during the civil war in the United States, when it was necessary to put into the market at once a large supply of cotton. The saw-gin is said to break the fiber of the cotton much more than the roller-gin, and for that reason many efforts have been made by the English spinners to suppress it. But in spite of these efforts the saw-gin remains master of the situation, and nowadays it is but rarely that any other kind is seen in Brazil, even in the remote interior. In every community in which cotton is grown there is at least one gin, the proprietor of which buys the unginned cotton from the planters and small farmers, cleans and bales it, and sends it to market. No use is now made of the cotton seeds. They are usually thrown out as so much waste. The cattle are allowed to eat what they choose, and sometimes they are used for fuel.

HOME CONSUMPTION.—Owing to the ease with which cotton is produced, the extent of its culture, the difficulty of getting the raw material into market from remote points, the evenness and mildness of the temperature, which, as a rule, does not require the warmer clothing of a more rigorous climate, the number of domestic purposes for which it is used, and the high tariff upon foreign manufactured goods, the home consumption of cotton is very large, and has steadily increased. In consequence of the decree prohibiting the use of looms, the cotton consumed in the country, until the beginning of the present century, was manufactured in the most aboriginal manner. About 1845 cotton factories began to spring up, and there are now no less than fifty spinning and weaving establishments in Brazil.

The manufacturing industry is at present confined almost wholly to the provinces of Rio de Janeiro, Minas Geraes, São Paulo, and Bahia, where the demand for the better grades of cotton cloth is greatest. But the factories have by no means done away with direct domestic consumption of raw material. To the traveler in the interior of Brazil there is no more familiar sight than that of spinning with the ancient distaff and spindle. In some parts of the country this custom is so common that the children learn it as a matter of course, and it would be very difficult to find a person who did not know how to spin. In order to show the wide-spread knowledge of this art in the interior, a Brazilian gentleman once assured me that it might be taken for granted that the then Brazilian prime minister could spin cotton in this aboriginal fashion. Very nearly all the hammocks used throughout the northern part of Brazil, together with considerable quantities of coarse cloth, are still made of thread spun in this manner. The

direct domestic consumption is about 1,162,000 pounds annually, which, with the amount made up by the factories and used in the country, makes the whole consumption of raw material in Brazil 18,481,600 pounds annually since the factories began operation.

PRODUCTION.—The total export from the whole empire from 1851 to 1876, inclusive, was 1,695,304,075 pounds. Add 27,900,000 pounds for the direct domestic consumption for the same period, and 69,276,400 pounds for the amount used by the factories during the four years from 1872 to 1876, and we have as the production of cotton by the whole empire, during the twenty-four years from 1851 to 1876, an average of 74,686,700 pounds per annum, or about twice as much as that of the State of Arkansas.

During the civil war in the United States, the exportation of cotton from Brazil assumed proportions hitherto unknown to that country. From the year 1850 to 1861 the average annual amount of cotton exported was 28,300,000 pounds. The exports rapidly increased from 21,400,000 in 1861 to 102,600,000 in 1868. As the United States recovered from the effects of the war, the amount of cotton exported from Brazil, although still large and fluctuating from year to year, was gradually decreasing, until in 1876 the exportation had fallen to 63,609,000 pounds. An impetus, however, was given to cotton culture in Brazil by the civil war in the United States which has been of great permanent benefit to the industry in that country.

Cotton in Brazil grows on its native soil, and, it is to be presumed, under climatic and other conditions best adapted to its highest development. But, though Brazil began to export cotton more than a hundred years before the United States, her annual product to-day is only about one eighteenth as much as our own. To be sure, the population is only one fifth as large as ours, but there almost the whole population lives in a cotton-growing region, while only a small part of our people live in the cotton belt.

Under normal conditions Brazil can scarcely become a competitor of the United States in cotton production; but the disappearance of slavery and the consequent adoption of some system of small farming will, in the near future, materially increase the present production. Slavery has fostered a remarkable conservatism in agriculture, which must, with the aid of educated planters, soon disappear. Cotton-factories are already rapidly springing up and prospering, and the day is not far distant when they will supply the Brazilian market.

The same agricultural tools and methods now employed by the average planters were in use more than two hundred years ago—methods learned from their Portuguese ancestors and from their African slaves. It is far from my intention, however, to criticise

these methods or the men who use them. The climate in which they live and the circumstances which have produced and retained these methods are so entirely different from our climate and our surroundings that any criticism from our standpoint would almost necessarily be unjust. The lack of capital and the lack of common roads are serious matters, no doubt, but they are not insuperable difficulties. Insect plagues that destroy from a fourth to a half of their crops are great drawbacks, but such questions should be regarded, not as visitations of God, before which man is powerless, but as practical matters to be met and dealt with as our planters are meeting and dealing with similar plagues in this country.

DARWINISM IN THE NURSERY.

By LOUIS ROBINSON, M. D.

WITHIN quite recent times we have learned that such seemingly trivial things as nursery rhymes and fairy tales are of the greatest importance in illustrating some points of the history and affinities of the human race, and also, in a less degree, in indicating the character of the ideas of our early ancestors concerning the forces and phenomena of Nature.

The value of the intense conservatism of the nursery in thus preserving for us, in an almost unchanged form (like ants in the resin of the Tertiary epoch or mammoths in the frozen tundra of the Quaternary), relics of the thoughts and customs of long ago has only begun to be appreciated; and doubtless if the nursery were less of a close preserve to the poachers and priers of science, and, like the beehive and the ant-hill, were available for purposes of investigation or experiment, we might considerably add to our knowledge concerning the history and habits of primitive man. At present there is a gap between embryology and anthropology which has never been filled up; and, oddly enough, with one or two exceptions, there have been hitherto no attempts to make use of the abundant material close at hand for the purpose of filling it. In this essay I propose to bring forward a few results of researches that have been carried out during several years under rather unusually favorable circumstances, in the hope that in some humble degree I may contribute to this end.

Some of the results obtained have been extraordinary, and the hesitation with which they have been received by some of my friends well versed in physiology and anthropology shows that hitherto the facts have escaped attention. They are, however, easily verified, and in several instances a single experiment performed in presence of a skeptic has cut short the controversy in a

satisfactory manner. Many of the inferences drawn are no doubt much more open to question, and they are here put forward chiefly with the purpose of drawing the attention of those much better able to judge of the value and bearing of the facts than the present writer.

It is curious how little has been written on the natural history of the human infant in its normal state. We have, of course, an abundant medical literature on the ailments and care of young children, but the many eminent physicians who have written on the subject have confined their attention almost entirely to abnormal or diseased conditions. Even in studying the healthy physiological processes the primary idea has been to gain the kind of knowledge which would be available in the treatment of disease rather than that which might illustrate the history of the development of the race, and this may easily account for many facts of very considerable value for the latter purpose being overlooked or not appreciated at their proper value.

It is plain that a typically healthy infant, in which Nature's processes go on without the interference of medical art, will, after the first crisis of its entry on an independent existence is over, scarcely come under the notice of the physician at all.

The three classes of persons who are brought into close enough contact with the objects under discussion to study their habits and characteristics are medical men, nurses, and parents. The first have been already dealt with. Of the second class we may say that their knowledge, although doubtless profound, and derived both from tradition and observation, does not seem very available for the purposes of sčience. This has hitherto been my experience, for although in nearly every case where questions were asked there was every assumption and appearance of superior erudition, yet it seemed almost impossible to tap the supply.

Parents, as a rule, from the very nature of their relationship to their offspring, are obviously unable to look on them with the cold, impartial gaze of the scientific investigator. At any rate, experience has proved that very little has resulted from their observations. The parental bias must, more or less, vitiate results; and the average mother, in spite of many unquestioned merits, is about as competent to take an unprejudiced view of the facts bearing on the natural history of her infant as a West African negro would do to carry out an investigation of the anatomy and physiology of a fetich.

There are some illustrious exceptions, and Darwin himself, in his Expression of the Emotions and Descent of Man, gives an account of some very interesting observations on several of his own children when infants. Several salient traits seem, however, to have completely escaped him, and some of these, which will be

dealt with in this paper, have a most important bearing on the argument on which he was then laying most stress, viz., that man is descended from an arboreal quadrumanous ancestor. The fact that such important and easily ascertained characteristics as those alluded to should have been passed over by one so keenly observant of all phenomena bearing upon his theory might suggest that the great man was scarcely so supreme in his own nursery as he was in the wider field of research, and that his opportunities for investigation were to some extent limited by the arbitrary and inflexible rules of this household department. In fact, the supposed interest of the Darwinian race, when conflicting with the interests of the Darwinian theory, appear to have become paramount somewhat to the detriment of the latter.

It has been well said that the development of the individual from the single germ-cell to maturity is an epitome of the infinitely longer development of the race from the simplest form of life to its present condition. No branch of science, not even paleontology, has thrown so much light on the evolution theory as the study of the structure and progress of the embryo up to the time of birth. There seems, however, no reason why embryology should stop here. An animal until independent of parental care, and even beyond that point, until the bodily structures and functions are those of an adult, is still, strictly speaking, an embryo; and we may learn much of its racial history by observing the peculiarities of its anatomy and habits of life.

For instance, among our domestic animals, horses and cattle live very much in the same manner, and thrive equally well grazing in open pastures. Yet a brief examination of the young of each shows that the habits and habitats of their respective wild ancestors were widely different. A foal from birth is conspicuous for the development of its legs, and when a few days old can gallop almost as fast as ever it will in its life. It makes no attempt at concealment beyond retiring behind its dam, and it carries its head high, evidently on the alert to see danger and flee from it. A young calf, on the contrary, is not much longer in the leg in proportion than its parents (I exclude, of course, the breeds artificially produced within quite recent times), and has but an indifferent turn of speed, and it is slow and stupid in noticing its surroundings. It has, however, one powerful and efficient instinct of self-preservation; for if, as is often the case in a bushy pasture, the mother leaves it under cover while she goes to graze, it will lie as still as death, and allow itself to be trodden on rather than betray its hiding-place. Hence we see that the ancestors of our domestic horses inhabited open plains where there was little or no cover, and that they escaped by quickly observing the approach of a foe and by speed. Wild cattle, on the contrary, as is still

seen in some parts of Texas and Australia, never from choice stray far from the shelter of the woods; and their ancestors, when threatened, lay couched among the bushes like deer, in the hope of escaping observation. It is very remarkable how quickly horses and cattle, though domesticated for thousands of generations, during which long period many of their wild instincts and habits have been entirely in abeyance, regain all the old power of self-preservation proper to the wild state, and often in a single generation become as acute in powers of scent and vision, and other means of escaping from their enemies, as animals which have never been tamed. There are at present probably no animals so alert and difficult to approach as the "brumbies," of Australia. In no way could more eloquently be shown the immense stretch of time during which these qualities were formed and became ingrained in the very nature and structure of their possessors than by comparing them with the trivial and evanescent effects of many centuries of domestication.

In the case of our own race it has often been observed that schoolboys present many points of resemblance to savages both in their methods of thinking—especially about abstract subjects—and in their actions. Younger children without a doubt also reflect some of the traits of their remote progenitors. If, as in the case of the calf and the foal, we look for traces of habits of self-preservation that for incalculably long periods were most necessary for the safety of the individual (and therefore for the preservation of the race), we shall find that such habits exist, and are impossible to explain on any other hypothesis than that they were once of essential service.

Take, for instance, the shyness of very young children and their evident terror and distress at the approach of a stranger. At first sight it seems quite unaccountable that an infant a few months old, who has experienced nothing but the utmost kindness and tender care from every human being that it has seen, should cling to its nurse and show every sign of alarm when some person new to it approaches. Infants vary much in this respect, and the habit is not by any means universal, though it is far more often present than absent. This would suggest that, whatever its origin, it was not for any very long period (in the evolutionary sense) absolutely necessary to preserve the species from extinction. Darwin merely alludes to the shyness of children as probably a remnant of a habit common to all wild creatures. We need not, however, go back to any remote ancestral form to find a state of affairs in which it might prove of the greatest service. We know that the cave-dwellers of the Dordogne Valley were cannibals, and that much later, when the races that piled together the Danish "kitchen middens" lived on the shores of the Baltic and German

Oceans, they were very much such savages as the present inhabitants of Tierra del Fuego, and lived after the same fashion. Like the Fuegians, they were probably divided into small clans, each of a few families, and these, from conflicting interests and other causes, would be constantly at war. The earlier palæolithic savages, living in caves and rock shelters, would be even more isolated and uncompromising in their treatment of strangers, for the game of any given district would only be sufficient to support a few. If in our day

> "Lands intersected by a narrow frith
> Abhor each other, mountains interposed
> Make enemies of nations,"

in the time of palæolithic and early neolithic man every district the size of an English parish would be the hunting-ground of a clan, with fierce enemies on every side. In such a state of affairs a stranger (unless he were safely tied to a stake) would be a most undesirable person in proximity to the wigwam and the picaninnies.

If he paid a call it would very likely be—in the scarcity of other game—with the purpose of carrying off a tender foe for table use. Under such circumstances the child who ran to its mother, or fled into the dark recesses of the cave, upon first spying an intruder would be more likely to survive than another of a more confiding disposition. Often, during the absence of the men on a hunting expedition, a raid would be made, and all the women and children that could be caught carried away or killed. The returning warriors would find their homes desolate, and only those members of their families surviving who, by chance or their own action, had escaped the eyes of the spoilers. On the approach of an enemy—and "stranger" and "enemy" would be synonymous—the child which first ran or crawled to its mother, so that she could catch it up and dash out of the wigwam and seek the cover of the woods, might be the only one of all the family to survive and leave offspring. Naturally the instinct which caused the child to turn from the stranger to the mother would be perpetuated; and from the frequency of the habit at the present day it seems probable that many of our ancestors were so saved from destruction. We must remember that the state of society in which such occurrences would be frequent lasted many thousand years, and that probably scarcely a generation was exempt from this particular and unpleasant form of influence.

When we bear in mind that the play of young animals is almost always mimic war, it is well worthy of note how very early young children will take to the game of "hide and seek." I have seen a child of a year old who, with scarcely any teaching, would

hide behind the curtains and pretend to be in great alarm when discovered. Probably the readiness with which infants play at "bo-peep," and peer round the edge of a cradle curtain, and then suddenly draw back into hiding, is traceable to a much earlier ancestor. Here we see the remains of a habit common to nearly all arboreal animals, and the cradle curtain, or chair, or what not, is merely a substitute for a part of the trunk of a tree behind which the body is supposed to be hidden, while the eyes, and as little else as possible, are exposed for a moment to scrutinize a possible enemy and then quickly withdrawn.

It is remarkable how quickly very young children notice and learn to distinguish different domestic animals. I have known several cases in which an infant under a year old, which could not talk at all, has recognized and imitated the cries of sheep, cows, dogs, and cats, and evidently knew a horse from an ox. Not infrequently I have heard great surprise expressed by parents at the quickness with which a baby would perceive some animal a long distance off, or when from other causes it was so inconspicuous as to escape the eyes of older persons. Pictures of animals, too, have a great fascination, and the child is never tired of hearing its playmate roar like a lion or bray like an ass when looking at them in the picture-book. This may seem of trivial import; but it is worth while to remember that the baby's forefathers for several thousand generations depended upon their knowledge of the forms and ways of wild beasts in order to escape destruction, either from starvation or from being overcome and devoured in contests with them; and that any and every individual who was a dunce at this kind of learning was in a short time eliminated. Hence an aptness to notice and gain a knowledge of different animals was essential to those who wished to survive, and a faculty so necessary, and so constantly operative through long ages, would be likely to leave traces in after-generations.

Among all arboreal apes the ability firmly to hold on to the branches is, of course, extremely important, and in consequence they have developed a strong power of grip in the hands. The late Frank Buckland compares the hands of an anthropoid ape to grapnels, from their evident adaptation to this end. Nor does this power exist only among adults, for although most apes, when at rest, nurse their young on one arm, just as does a mother of our own species, when, as often happens, they are fleeing from an enemy, such as a leopard or some other tree-climbing carnivorous animal, the mother would need all her hands to pass from branch to branch with sufficient celerity to escape. Under such circumstances the infant ape must cling on to its mother as best it can; and naturalists who have repeatedly seen a troop of monkeys in full flight state that the young ones as a rule hang beneath the

necks and breasts of the mothers, holding on by the long hair of their shoulders and sides. This was the case with a young Rhœsus monkey born in the Zoölogical Gardens. Wallace, in his Malay Archipelago, gives an account of a very young orang which he secured after shooting the mother. He states that the baby orang was in most points as helpless as a human infant, and lay on its back, quite unable to sit upright. It had, however, an extraordinary power of grip, and when it had once secured a hold of his beard he was not able to free himself without help. On his taking it home to his house in Sarawak he found that it was very unhappy unless it could seize and hold on to something, and would lie on its back and sprawl about with its limbs until this could be accomplished. He first gave it some bars of wood to hold on to, but, finding it preferred something hairy, he rolled up a buffalo-skin, and for a while the little creature was content to cling to this, until, by trying to make it perform other maternal duties and fill an empty stomach, the poor orphan mias nearly choked itself with mouthfuls of hair and had to be deprived of its comforter. The whole story of this poor little ape is both amusing and pathetic, as well as instructive, and I can not do better than refer those not already acquainted with it to the book, which is as a whole as good an introduction for the young student to the science of evolution as could well be found.

This power to hold on to the parent in any emergency may be compared to the galloping power of the young foal and the instinct of concealment in the calf; it is the one chief means of self-preservation adopted by the young of the arboreal quadrumana. During long epochs, impossible to measure by years, it would constantly be exercised; and it is plain that every infant ape that failed to exercise it, or which was physically unable from any cause to cling to its mother, when pursued by an agile foe, would either fall to the ground or be devoured among the branches. When we consider the harassed and precarious life of all wild creatures and the number of their enemies, it becomes apparent that scarcely an individual would be exempt from being many times put to the test, and the habit would, by the survival of those only which were able to maintain their grip, become more and more confirmed, until it became an integral part of the nature of all quadrumana and their descendants.

This being so, it occurred to me to investigate the powers of grip in young infants; for if no such power were present, or if the grasp of the hands proved only to be equally proportionate to any other exhibition of muscular strength in those feeble folk, it would either indicate that our connection with quadrumana was of the slightest and most remote description, or that man had some other origin than the Darwinian philosophy maintains.

In The Luck of Roaring Camp every one will remember the expression of one of Bret Harte's mining ruffians after he had passed through the shanty containing the newly born "Luck" and the corpse of the wretched mother. "He wrastled with my finger," said Mr. Kentuck, regarding that member with curiosity, and characteristically adding some adjectives more emphatic than to the point. On reading the story aloud in company several years ago a discussion arose as to whether the novelist was as correct an observer of infant human nature as he doubtless was of the vagaries of the pious cut-throats and chaste courtesans of the Pacific slope in the golden days of '49, and considerable doubt was thrown on the statement of Mr. Kentuck, since it did not seem probable that so gelatinous and flabby a creature as a newborn babe could "wrastle" (and prevail) even with a finger. Subsequent observation proved that the novelist here did not go beyond Nature's warrant, and that, whatever doubts we may have of the disinterestedness of Mr. Oakhurst, or the constancy of "Miggles," "The Luck" was drawn true to type.

Finding myself placed in a position in which material was abundant, and available for reasonable experiment, I commenced a series of systematic observations with the purpose of finding out what proportion of young infants had a noticeable power of grip, and what was the extent of the power. I have now records of upward of sixty cases in which the children were under a month old, and in at least half of these the experiment was tried within an hour of birth. The results as given below are, as I have already indicated, both curious and unexpected.

In every instance, with only two exceptions, the child was able to hang on to the finger or a small stick three quarters of an inch in diameter by its hands, like an acrobat from a horizontal bar, and *sustain the whole weight of its body* for at least ten seconds. In twelve cases, in infants under an hour old, half a minute passed before the grasp relaxed, and in three or four nearly a minute. When about four days old I found that the strength had increased, and that nearly all, when tried at this age, could sustain their weight for half a minute. At about a fortnight or three weeks after birth the faculty appeared to have maintained its maximum, for several at this period succeeded in hanging for over a minute and a half, two for just over two minutes, and one infant of three weeks old for *two minutes thirty-five seconds!* As, however, in a well-nourished child there is usually a rapid accumulation of fat after the first fortnight, the apparently diminished strength subsequently may result partly from the increased disproportion of the weight of the body and the muscular strength of the arms, and partly from the neglect to cultivate this curious endowment. In one instance, in which the performer had less than one hour's

experience of life, he hung by both hands to my forefinger for ten seconds, and then deliberately let go with his right hand (as if to seek a better hold) and maintained his position for five seconds more by the left hand only. A curious point is, that in many cases no sign of distress is evinced, and no cry uttered, until the grasp begins to give way. In order to satisfy some skeptical friends I had a series of photographs taken of infants clinging to a finger or to a walking-stick, and these show the position adopted excellently. Invariably the thighs are bent nearly at right angles to the body, and in no case did the lower limbs hang down and take the attitude of the erect position. This attitude and the disproportionately large development of the arms compared with the legs, give the photographs a striking resemblance to a well-known picture of the celebrated chimpanzee "Sally" at the Zoölogical Gardens. Of this flexed position of the thighs, so characteristic of young babies, and of the small size of the lower extremities as compared with the upper, I must speak further later on; for it appears to me that the explanation hitherto given by physiologists of these peculiarities is not altogether satisfactory.

I think it will be acknowledged that the remarkable strength shown in the flexor muscles of the forearm in these young infants, especially when compared with the flaccid and feeble state of the muscular system generally, is a sufficiently striking phenomenon to provoke inquiry as to its cause and origin. The fact that a three-weeks-old baby can perform a feat of muscular strength that would tax the powers of many a healthy adult—if any of my readers doubt this let them try hanging by their hands from a horizontal bar for three minutes—is enough to set one wondering.

So noteworthy and so exceptional a measure of strength in this set of muscles, and at the same time one so constantly present in all individuals, must either be of some great utility now, or must in the past have proved of material aid in the battle for existence. Now it is evident that to human infants this gift of grip is of no use at all, unless indeed they were subjected to a severe form of an old south of England custom, which ordered that the babe, when three days old, should be lightly tossed on to the slope of a newly thatched roof, that it might, by holding on to the straw with its little hands, or by rolling helplessly back into the arms of its father, assist in forecasting its future disposition and prospects in life. Barring the successful passing of this ordeal—with regard to which I have never heard that non-success was a preliminary to immediate extinction—it seems plain that this faculty of sustaining the whole weight by the strength of the grasp of the fingers is totally unnecessary, and serves no purpose whatever in the newly born offspring of savage or civil-

ized man. It follows therefore that, as is the case with many vestigial structures and useless habits, we must look back into the remote past to account for its initiation and subsequent confirmation; and whatever views we may hold as to man's origin, we find among the arboreal quadrumana, and among these only, a condition of affairs in which not only could the faculty have originated, but in which the need of it was imperative, since its absence meant certain and speedy death.

It is a well-known fact that the human embryo about three months before birth has a thick covering of soft hair, called "lanugo," which is shed before a separate existence is entered upon. At the same stage of development the skeleton is found to conform much more to the simian type than later, for the long bone of the arm, the humerus, is equal to the thigh-bone, and the ulna is quite as long and as important as the tibia. At the time of birth the lower limbs are found to have gained considerably on the upper, but still they are nothing like so much larger as when fully grown. Physiologists have explained this want of development of the lower extremities in the fœtus by attributing it to the peculiarity of the ante-natal circulation, in which the head and arms are supplied with comparatively pure oxygenated blood fresh from the maternal placenta, and the lower part of the trunk and legs get the venous vitiated blood returned through the great veins and transferred *via* the right ventricle and the *ductus arteriosus* to the descending aorta. This, it is said, accounts for the more rapid growth and more complete development of the head and arms before birth. To assert the exact contrary would be to contradict several great authorities, and apparently to follow the lead of the pious sage who admired the wisdom and goodness of Providence in causing large rivers to flow by great cities. Nevertheless it is well to remember that just as the Sabbath was made for man, and not man for the Sabbath, so the blood-vessels were made for the body and not the body for the blood-vessels. It appears to me much more true to say that the quick arterial blood is sent to the upper extremities because these parts are for the time being more important, and their growth and development essential to the welfare of the individual, than that they are coerced into a kind of temporary hypertrophy, *nolens volens*, through having a better blood-supply arbitrarily sent them than is allotted to their nether fellow-members. That this view is borne out by facts can be shown by taking the example of a young animal whose hind quarters are of essential service to it from birth; and for this end we need go no further than the instance, already quoted, of the young foal. Now, in the ante-natal state the foal has just the same arrangement of blood-distribution as the embryo man; yet he is born with a small light head and well-developed hind quarters, so

that he can gallop with speed. Instead of coming into the world with the general outline of an American bison (as he ought to do upon accepted physiological dicta), he is, as is well known, proportionately higher at the rump and lower at the shoulder than in after-life. The mention of the American bison reminds me that it is another capital illustration of the same fact; for a young buffalo calf must have speed from its earliest days to enable it to keep up with the herd on the open prairie; and, in consequence, we find that it is much better developed behind (the hind legs being the chief propellers in all galloping animals) than the full-grown bull or cow, and has none of the comma-like, whittled-off aspect of its adult parents. The massive fore end of the bull bison arises from his habit of using himself as a projectile wherewith to batter his rivals out of the overlordship of the herd; but the bison calf is almost as level-backed as the young of our domestic cattle—though it is a much more active, wide-awake little beast than an ordinary calf.

Why, then, are the head and upper extremities so apparently abnormally developed in the young infant? I conceive the true reason to be something like this: For untold ages the perfection of the arms was a *sine qua non* of the continuance of the race; and as man, or the thing which was to be man, took to living by his wits—when, that is, *mind* began to take precedence of brute force and direct reflex action in the forefront of the struggle for existence—it became an absolute necessity for the being that was to live by his wits to be furnished with an abundant supply of the raw material out of which wits are made—that is, brains. Now, every man, actual or *in posse*—having elected, be it remembered, to fight chiefly with his brains, and having renounced forever the more gross and carnal weapons, such as huge canine teeth and heavy, claw-armed limbs—would be certainly bested in the struggle, and driven out of being, if his chosen armature were not up to the mark. In other words, every incipient *homo* who was born with deficient mind-material lived but a short time and left no offspring. And, since the potentialities of the brain depend far more upon its primary degree of development than do, for instance, the potentialities of the muscles, only those infants which were born with crania capacious and well-furnished would attain that degree of excellence which would prevent them from being fatally plucked in Nature's great perennial competitive examination. Only those infants, then, survived and became our ancestors which had from the first a good development of head and arm, and, to insure this, Nature has provided for a suitable blood-supply during the early period of growth.

With regard to the forward bend of the thighs in young infants, which is constant in all cases, as any one who has the opportunity

for observing can see for himself, this has been accounted for from the fact that the thighs are flexed against the abdomen during the latter part of intra-uterine life. But from analogy with other young creatures, such as those already mentioned and young birds, we find that the pre-natal position has little or no influence in decreeing the habitual attitude of the limbs after birth, and it seems to me more logical and reasonable to trace this also to a prior state of evolutionary development.

Man is, when standing erect, the only animal that has the thigh in a line with the axis of the vertebral column, and among his nearest congeners in the animal world the flexed state of the femoral articulation is natural and constant. As we go down the scale the angle between the thighs and trunk diminishes, until it reaches the right angle characteristic of most quadrupeds. I speak here of the attitude adopted when the animal is at rest upon its legs, for during sleep there is in many cases a curious reversion to the position occupied in embryonic life. Thus we see that a bird roosting with its head "under its wing," and the legs drawn up close to the body, offers a decided resemblance to the chick in the egg.

I have noticed that young children, when old enough to shift their limbs, very seldom sleep in any but the curled-up position; and that as often as not, when unhampered by clothing or other artificial restraints, they sleep in the same attitude as do many quadrupeds, viz., with the abdomen downward and the limbs flexed beneath them. I am told that negro mothers and nurses in the West Indies invariably lay their charges down to sleep on their stomachs, and that this custom is also common in various parts of the world. Adult man is, I believe, the only animal who ever elects to sleep upon his back. Some of the lower savages seem to sleep comfortably on occasion in a crouching position with the head bent down upon the knees, just as all the common tribes of monkeys do. Among the quadrumana it is not until we come to the platform-building anthropoid types that we find a recumbent position habitually taken during sleep. The young orangs and chimpanzees that they have had at the Zoölogical Gardens slept with the body semi-prone and with the limbs, or all except one arm, which was used as a pillow, curled under them. This is exactly the position voluntarily adopted by eighty per cent of children between ten and twenty months old which I have had opportunities of watching. I was told by the attendants at the Zoölogical Gardens that no ape will sleep flat on his back, as adult man often does.

It would be very interesting to get exact observations as to the habits of all the lower tribes of men with regard to sleeping, for it is a point upon which a great deal would seem to depend, if,

as Tylor and most of our anthropologists believe, man's first ideas of a spirit world arose from dreams. We know that most of our domestic animals dream, as is proved by their movements while asleep, and the same thing has also been observed in monkeys. The effect of the position of the body during sleep upon the character of our dreams is too well known to require comment, for probably every one of my readers has experienced the very disagreeable results of sleeping on the back.

Now, if the first glimmerings of another world came to early man through dreams, in which he saw his comrades, or enemies, long since dead, reappear just as in life, though mixed up with much that was incongruous and incomprehensible, it would seem as if the period during which man first adopted the *dorsal decubitus* might have been an epoch-making time in his raw theology.

Devils and devil-worship might easily have originated from a nightmare; and since even dogmas have pedigrees and are subject to the laws of evolution, it is perhaps no very wild suggestion that some of the more somber tenets of our gentle nineteenth-century creeds may owe their embryonic beginnings to the sleeping attitude of some palæolithic divine who had gorged himself in an unwise degree with wild-boar flesh.—*Nineteenth Century.*

SKETCH OF WILLIAM FERREL.

By Prof. WILLIAM M. DAVIS.

SIXTY years ago, the study of meteorology gained a notable impetus from the discoveries then recently made concerning the phenomena of storms. The tempestuous winds had been called to order by the investigations of Dové and Redfield, followed by those of Reid, Piddington, and others in the succeeding decades, and even the literary quarterlies contained reviews of books treating revolving gales. But at that time the understanding of the general circulation of the atmosphere about the earth had hardly advanced from its position early in the eighteenth century, when Hadley first and incompletely explained the oblique course of the trade-winds, as a consequence of their motion upon a rotating globe. In the middle of our century, Dové, then the leader of European meteorologists, taught that all our northeast winds were portions of the return current from the poles, whose battling with the equatorial current gave us our alternations of wind and weather in the temperate zone. In this country, the most commonly accepted explanation of atmospheric circulation was derived from Maury's fascinating Physical Geography of the Sea—a book whose erroneous teachings concerning the source

of our rains in evaporation from the South Pacific Ocean, and concerning the northeast-southwest course of the return polar current at great altitudes, still find recent advocacy by those who would persuade us that cannonading will cause rainfall.

The meteorology of to-day is another science from that of those earlier decades. The store of facts has increased wonderfully, both from the observations made at sea, in good part as a result of the incentive given by Maury, and from the establishment of weather services in many countries following the suggestions of Espy, Henry, Leverrier, and others. The hydrographic offices of various governments have charted the winds of the oceans; Buchan has determined the distribution of barometric pressure over the world, Loomis has discussed more fully than any one else the features of the cyclonic storms whose action is so well indicated on the weather maps.

But from whom has the finer spirit of understanding of all these facts been received? From whom have we now gained an insight into the wonderful correlations that exist among the varied motions of the atmosphere? We would not belittle the ingenious theories of Espy, to whom greater honor is given with the passing years; we would not forget the many contributions made by earnest students at home and abroad; but the fuller appreciation of the system of the winds, both great and small, both in the full sweep of the terrestrial circulation and in the constricted whirl of the tornado, comes from one man—a man lately described by the leading meteorologist of Europe as one "who had contributed more to the advance of the physics of the atmosphere than any other living physicist or meteorologist—a man of whom Americans are justly proud."* Alas that this man is no longer living, and that so few Americans know how proud they may be for having had him for a countryman!

WILLIAM FERREL died on September 18, 1891, at Maywood, Kansas, in his seventy-fifth year. The first half of his life was a struggle against adverse circumstances in uncongenial surroundings. His later years saw him on the staff of the Nautical Almanac, in charge of tidal computations in the Coast Survey, Professor of Meteorology in the Signal Service, member of the National Academy of Sciences, and our recognized leader in scientific meteorology. Let those of us whose paths of life have been opened by the labors of our fathers marvel at the innate powers of such a man as this, who made his own way through heavy discouragements.

Ferrel was born in Bedford (now Fulton) County, Pa., on Jan-

* Dr. Julius Hann, Director of the Austrian Meteorological Observatory, in the Proceedings of the Vienna Academy of Sciences, April 9, 1891.

uary 29, 1817. We are fortunate in having from his own hands a record of his early years. At the request of Mr. A. McAdie, of the Signal Service, Prof. Ferrel wrote, in 1887, an account of his life, and from this Mr. McAdie prepared a biographical sketch that was published in the American Meteorological Journal for February, 1888. The same journal for December, 1891, contains several notices of Ferrel's works by Newcomb, Abbe, and others, read at the October meeting of the New England Meteorological Society. A list of his published writings is given in the Journal for October of the same year. The manuscript autobiography has been presented by Mr. McAdie to the Library of Harvard College, and the following account of Ferrel's youth is prepared from it. Although never widely known, even among our scientific men, his work since his fortieth year gives a record of the latter part of his life; and for that reason the narrative of his earlier years is here given more fully. It is one that may certainly inspire young men who labor under discouragement; and perchance it may also lead the more generous of our readers to seek out and lend a helping hand to those whose lines are hard and who are working earnestly to help themselves; not that all such shall become Academicians, but that well-timed help extended in such directions is the best investment that a man can make for himself and for his country.

Ferrel's father was of Irish and English descent; his mother came from a German family. They lived in a simple way in the country, and the boy went to a common district school. In 1829 the family moved across the narrow western arm of Maryland into Berkeley County, Virginia (now West Virginia). There the son was kept closely at work, except while at school for two winters, the school-house being a rude log cabin, in which he went. "through the arithmetic and the English grammar," and then remained out of school till 1839. Having mastered his school-books, he had nothing further to study except a weekly newspaper, the Virginia Republican, published at Martinsburg; this he waited for eagerly, to read its occasional scientific items.

While thus engaged on the farm young Ferrel saw somewhere a copy of Park's Arithmetic, with a sketch of mensuration at its close. Of this he writes: "At the sight of the diagrams I was at once fired with an intense desire to have the book. But I had no money, and at this time I was too diffident to ask my father for even a half-dollar, or to let him know that I wanted the book. Soon afterward I earned fifty cents in the harvest-field of one of the neighbors, and with this I determined to buy the book. The first time I had a chance to go to Martinsburg I inquired for it at a store, but learned that its price was sixty-two cents. I told the store-keeper I had only fifty cents, and so he let me have it at

that price. It was a light task to learn all that was in it." One can not forbear to moralize over this intense desire for knowledge, for what would not such a boy have learned with proper encouragement and opportunity! It must be to these and the succeeding years of hampered effort that Ferrel refers in a few sad words at the close of his narrative: "Much of my time has been wasted, especially the earlier part of it, because, not having scientific books and scientific associations, I often had nothing on hand in which I was specially interested."

It may be said that Ferrel began his career as an investigator in 1832, when on going out one day to work he noticed that the sun was eclipsed. He had not known that such an event was to occur, but it set him to thinking. He had somewhere learned the cause of solar and lunar eclipses, but his materials for further study were only a German calendar, such as farmers use, and a copy of Adams's Geography, with an appendix giving problems on the use of the globes. From these he found that the sun and moon moved with unequal velocities in different parts of their orbits, and that the fastest and slowest motions were at opposite points. Of this he writes: "My theory was that the earth and the moon moved with uniform velocity in circular orbits, and that these orbits were eccentrically situated with regard to the sun and earth. With regard to the moon's path, I knew that it crossed the ecliptic, but I did not know at what angle, and I also at first supposed that the node was fixed. At the beginning of the next year, when the next calendar came to hand, I discovered from the predicted eclipses that the node must recede. I saw from the calendars that there was some cycle of nineteen years, and suspected that this had something to do with the moon's node. This would make the node recede about 19° in a year, as the next year's eclipses seemed to require." Then, with the aid of some older calendars, Ferrel, about at the age of sixteen, proceeded to make out tables of the dates of eclipses in an empirical fashion, but he unfortunately assumed that the diameter of the earth's shadow was constant. "Upon this assumption I spent a vast amount of time, but could get no positions of the nodes or inclination of the orbit which would satisfy the eclipses. The amount of study I gave to the subject both day and night was very great, but I at last gave the matter up in despair. Some time after I was at work one day toward evening on the thrashing-floor, and saw the shadow of a distant vertical plank against the wall; I observed that it was much smaller than the width of the plank, and the reason for it occurred to me at once. I then saw the error of my assumptions with regard to the earth's shadow in my eclipse investigations and was now very anxious to go over again all my computations with the true diameter of the earth's shadow, for, knowing the dis-

tance of the moon and the angular diameter of the sun, I was able to determine this. As soon as I could find time I went over the whole work, and everything came out as satisfactory as could reasonably be expected with my methods. . . . This was in the winter of the first part of 1834. I now ventured to predict by my method the eclipses for the next year, 1835. I determined that there would be three eclipses—two of the moon and one of the sun. . . . I made a record of the whole in a book and awaited for the next calendar for comparison with its predictions. All the circumstances of the lunar eclipses agreed remarkably well, and the greatest error in the predicted times was only nine minutes." And this was the work of a farmer's boy, without help, without encouragement, in the time that he could spare from daily work!

His next book seems to have been Gummere's Surveying, which he mastered in the spring of 1834, with the exception of the miscellaneous examples at the end of the volume, for which no rules had been given and which required a knowledge of geometry. "During the summer, as I had a little time to spare, I dwelt upon these, giving weeks sometimes to a single proposition. It happened that during the summer I was engaged a good part of my time on the thrashing-floor, which had large doors at both ends with wide and soft poplar planks. Upon these I made diagrams, describing circles with the prongs of large pitchforks, and drawing lines with one of the prongs and a piece of board. One by one I mastered all the problems in this way except three. For more than a quarter of a century these diagrams were visible on the doors, and, in returning occasionally to the old homestead, I always went to take a look at them."

This kind of home study continued until 1839, when Ferrel went to Marshall College, at Mercersburg, Pa. Here he learned algebra, geometry, and trigonometry, and gave some time also to Latin and Greek. The next winter he taught near home; but in 1840 he returned to Marshall It was in this year that one of his professors assigned original problems in mathematics to the class. "On one occasion he gave the problem: Given the distances of a well from the three angles of an isosceles triangle, to determine the triangle. . . . This was easy to me at the time, for it was one of the problems which I had solved while at work on the thrashing-floor, with the use of diagrams on the barn-doors, before I had seen a college or a treatise on algebra or geometry."

His money was exhausted in the latter part of 1841, and he went home to teach for two years. Bethany College was then opened in Virginia, and he was admitted to the senior class, and graduated in 1844. It is curious to notice that during all these years there is no mention of apparatus, experiments, or systematic

observations; the boy's work, like that of the man afterward, was almost entirely internal and mental. Thus, at the age of twenty-seven, his schooling was ended, and he left his home and went to Missouri to teach. Failing health compelled him to stop work for a time, and his next engagement was at a small school in Kentucky, where he remained for seven years, until 1854.

While in Missouri he had happened on a copy of Newton's Principia, ordered but never called for by an earlier teacher; he bought it for five dollars, making little advance then on account of poor health, but later returned to it in Kentucky. "I now became first interested in the tides, and conceived the idea that the action of the moon and sun must have a tendency to retard the earth's rotation on its axis. Knowing that Laplace had treated the subject extensively in the Mécanique Céleste, I was very desirous of obtaining a copy, mostly to see what he had in that subject. I accordingly instructed a village merchant, on going to Philadelphia for a supply of goods, to procure me the work, having little idea of the magnitude of the work or the cost. On learning the cost at Philadelphia, he did not procure it for me until after writing and hearing further from me. I had now plenty to study in connection with my teaching for several years." From this followed Ferrel's first scientific paper, On the Effect of the Sun and Moon on the Rotary Motion of the Earth, a subject to which he returned with success in later years.

In the spring of 1854 Ferrel went to Nashville, Tenn., and opened a private school; here Prof. W. K. Bowling, of the Medical College, became his warm friend, and here he first turned his attention to meteorology, from meeting with Maury's Physical Geography of the Sea. "From this book I first learned that the atmospheric pressure was greatest near the parallels of 30°, and less at the equator and in the polar regions; and I at once commenced to study the cause of it. . . . In conversation one day with my friend Dr. Bowling, I told him I had read Maury's book, and he was at once desirous of knowing what I thought of it. I told him that I did not agree with Maury in many things. He then desired me to 'pitch into him,' as he expressed it, and furnish a review for his Journal of Medicine. This I declined to do, but at length consented to furnish an essay on certain subjects treated in the book, and notice Maury's views a little in an incidental way." This was the beginning of the studies in meteorology, which gave a new aspect to the science. The promised article was his Essay on the Winds and Currents of the Ocean. It has since been republished by the Signal Service in Professional Paper No. XII.

In the spring of 1857 the third period of Ferrel's life began on his accepting an offer from Prof. Winlock, transmitted through Dr. B. A. Gould, to take part in the computations for the Nauti-

cal Almanac, then prepared in Cambridge, Mass., and thus opened the happier situation of his later years; but it was not until the spring of 1858 that he finally left Nashville. From this time on he did not lack opportunity for study and acquaintance with scientific men. In 1867 he joined the Coast Survey, then under the superintendence of Prof. Benjamin Peirce, and remained in that service until 1882. The chief results of his work during this period were his Tidal Researches, Meteorological Researches, and his Tide-predicting Machine, all of which contribute to his well-earned reputation.

Ferrel's researches on the tides were in both theoretical and practical directions. His theoretical discussions began in his days of teaching in Kentucky, and in 1853 had led him to conclude that the action of the tides would very slightly retard the rotation of the earth, but at that time no indication of such retardation had been found by astronomers. In 1860, however, it was found that the position of the moon was somewhat in advance of its calculated position; all the known effects of external perturbations having been allowed for, its advance still was unexplained. Ferrel, then living in Cambridge, returned to this problem and showed that the moon's unexplained advance might be accounted for as only an apparent result, the real fact being a retardation of the earth's rotation by tidal action. The essay on this subject was published in the Proceedings of the American Academy of Arts and Sciences in Boston in 1864. An incident in this connection illustrates the diffidence that Ferrel felt in coming in contact with strangers. He carried his essay on The Influence of the Tides in causing an Apparent Secular Acceleration of the Moon's Mean Motion in manuscript to the meetings of the Academy time after time, with the intention of reading it, but his courage always failed, until at last the paper was presented in 1864. Had its presentation been deferred over one more meeting, its appearance would not have antedated a similar essay by the French astronomer, Delaunay, on the same subject.

This was before Ferrel was a member of the Coast Survey; it was naturally followed by his engagement as expert in tidal studies in that office; and when afterward in Washington, he discussed and reduced many tidal observations made at various points on our coast. To lighten the labor of such computations he invented a tide-predicting machine, by means of which the time and value of high and low tides can be mechanically determined for various ports with sufficient accuracy for publication in the official tables, after the constants for the ports are worked out. This machine is now in regular use in Washington, where it is regarded as doing the work of thirty or forty computers. A general work on tides and their theory was among the latest stud-

ies that Ferrel undertook, to be stopped only by the illness that caused his death.

In 1882 Ferrel accepted a professorship in the Signal Service, producing while there several special reports of high value, among which his Recent Advances in Meteorology should have first mention. He also lectured to the officers of the Signal Corps at Washington, and it is from these lectures that he subsequently prepared his Popular Treatise on the Winds, the most comprehensive statement of theoretical meteorology in the English language. He resigned this professorship in 1886, in his seventieth year. He had before this accumulated a competence from judicious investments of the small earnings of earlier years.

Ferrel's name is chiefly connected with his original investigations in meteorology. The first of these was made at Nashville, as stated above, but a more serious study was made in his Motions of Fluids and Solids relative to the Earth's Surface, prepared shortly after going to Cambridge, and published in Runkle's Mathematical Monthly. This is regarded by a most competent critic as "the starting-point of our knowledge of the mechanics of the atmosphere." It is here that he first clearly states the important law that "in whatever direction a body moves on the earth's surface there is a force arising from the earth's rotation which tends to deflect it to the right in the northern hemisphere, but to the left in the southern." This was published in May, 1858, six months before it was discussed, with the same result, in the French Academy of Sciences. Space can not be given here to show the great importance of this principle in meteorology, but if the reader desires to follow it to its applications he should consult the Treatise on the Winds, named above. As to the importance of the principle, let any one attempt to explain the motions of the wind and the distribution of atmospheric pressures without it, and he will soon see the service rendered to meteorology by Ferrel in its introduction. The essential quality of this principle may perhaps be briefly stated.

The general conception of the theory of the winds refers them to convectional movements, arising from the action of gravity on parts of the atmosphere of different temperatures. According to this, the poles, where the temperatures are low, should have high pressures, and the occurrence of low pressures there has been a stumbling-block to more than one writer on the subject; indeed, hardly an English text-book can be named that will lead the student around this difficulty. The consideration introduced by Ferrel is to the effect that the actual distribution of pressure does not depend only on differences of temperature, but also on the motions excited by reason of the pressure differences. The condition of steady motion, under which the winds are impelled by an

acceleration just sufficient to overcome their resistances, requires that the acceleration should be not only the small component of gravity acting on the barometric gradient, but the much smaller resultant of this component acting with the deflective force arising from the motion of the wind itself. The course adopted by the established interchanging circulation between the equator and the poles consists for the most part of a great circumpolar whirl from west to east; and the deflective forces here in play reduce the polar high pressures to low pressures. A reactionary relation therefore exists between the winds and the pressures, by which the distribution of pressures according to temperature alone is greatly modified. Instead of finding high pressure at the cold poles, a low pressure is produced there by the great circumpolar whirl of the general winds, and the air thus held away from the poles accumulates around the tropical belts of high pressure, of which Ferrel had first learned from Maury's book. The absence of northeast return currents (in this hemisphere), except in the trade-wind belt, is as important a feature of Ferrel's theory as the reversal of polar high pressure into low pressure. Maury's erroneous explanation of the winds gained great acceptance from the attractive style in which his book was written; but it is time that his explanation should be abandoned even in elementary teaching, and replaced by more serious views, less easily acquired but of more permanent value.

Ferrel's theory of the winds not only explains the general distribution of atmospheric pressure over the world, as no other theory can do; it introduces broad correlations among many phenomena in meteorology, greatly to the advance of the science. The legitimate analogies that may be drawn between the great circumpolar whirl of the terrestrial winds, the smaller whirls of tropical cyclones, and the concentrated whirling of tornadoes show the unity of action of the convectional processes in the moist atmosphere of a rotating planet. In earlier years, meteorology consisted chiefly of rules for observation and statistical study. The broad generalizations taught by Ferrel raise the science from this simple inductive condition and complete the philosophical rounding of its parts.

Ferrel was not an observer, but he carefully based his studies on well-ascertained facts. He was not an experimenter, but he followed the results obtained by the best physicists. He was a reasoner, able to employ the stronger methods of mathematical analysis. He was sincere and judicial, single-minded and simple-hearted. No one criticised his results more carefully or deliberately than he did himself. He was indifferent to popularity, and took little trouble to enforce his views on the world. He lived a quiet life, more with books than with men, although the few to

whom his closer friendship was given prized it highly. From his isolation as a boy and young man, he was diffident, even to his own embarrassment, in going out to meet others; but to those who came to him he was generous and sympathetic in giving assistance. He never pushed himself forward, and all his official positions came unsought. His earlier essays were inconspicuously published, and never had a wide circulation, even in separate pamphlet form. Many who have received them must have passed them by hardly noticed. The attention of scientific men turned slowly to his work; only in later years than 1870 is his name often mentioned abroad. His preference was always for original methods, in his college demonstrations as well as in later investigations. He did little in the way of restatement of the conclusions of others, but liked better to give his time to original researches in which there was a prospect of discovering something new or of explaining facts that had not been explained before. When his interest was aroused in such work, he devoured everything that he could find about it, "studying almost day and night," and never giving up a problem until it was solved, or until he was satisfied that his labors could not solve it. His conquest of physical problems was not the result of intuitive perceptions alone, but followed patient and persevering work. This appears in his boyhood when he pondered over geometrical problems in the barn, and in later years when his meteorological theories gradually developed.

Ferrel was a man whose teachings reach slowly through the world. Many of the problems that he solved bear only remotely on the lives of the millions of unmarked men from among whom he won his way to eminence; but all who read of him may understand the lesson of his courageous perseverance, of his earnest work and of his simple life. They will do well if, even without adding much to the world's store, they can say as he did at the close of life, "I regret to leave my friends, but that is all I regret."

ATTENTION was drawn by Miss Buckland, at the British Association, to numerous points in which the Navajo myth entitled "The Mountain Chant" reproduces customs and beliefs of the Old World. Among them were mentioned the singular prohibition of food in the abode of spirits, such as appears in the classical story of Persephone, and in modified shape in the fairy folk lore of Europe, in Aino and Japanese tales, and in New Zealand. The author pointed out the great contrast between the bloodless Navajo rites and the sanguinary ceremonies of the ancient Mexicans, and the great dissimilarity in the forms of the Navajo and Mexican gods, as denoting entirely different origins for the two religions, incompatible with the belief commonly entertained of the wholly indigenous character of American culture, and she urged that the Navajo rites point unmistakably to an Eastern origin.

CORRESPONDENCE.

INTELLIGENCE AND THE BELIEF IN EVOLUTION.

Editor Popular Science Monthly:

SIR: Two sentences in your Editor's Table of the January (1892) number excite my surprise. They are these: "Every man within certain limits is an evolutionist, and we have little hesitation in saying that the limits within which each man is an evolutionist are the real limits of his intelligence"; and "we believe—and when we say 'we' we mean all persons with any pretensions to education or intelligence—in evolution as applied to the physical history of our globe." Are these statements consistent with that judicial fairness which all seekers for truth, such as you certainly mean to be, should preserve?

There are many of us who have been diligent students of the works of evolutionists from the appearance of Herbert Spencer's First Principles in 1865. We have read Darwin's volumes carefully, and Huxley's and Tyndall's. We have followed Prof. Gray's beautiful essays. But we are as yet unconvinced "of evolution as applied to the physical history of our globe." There are gaps in the chain which, to our mind, are not filled, nor are in promise of being filled, in material evolution, as at the beginning of *life*. We accept the statement of the authors of The Unseen Universe: "It is against all true scientific experience that life can appear without the intervention of a *living* antecedent." Also at the appearance of new organs, as Prof. Samuel Harris says, after giving Prof. Tyndall's description of the development of the eye: "This certainly is not science; no fact sustains *a single one* of the assumptions. It is a figment of fancy." Then there is the gap between the brute and rational man, where we see *no approach* to a bridge.

Besides this, it seems to us there is much sophistical reasoning among evolutionists, as pointed out by Rudolph Schmid, by S. Wainwright, and especially by Prof. Samuel Harris, in his Scientific Basis of Theism.

There is, too, an initial difficulty in the getting the heterogeneous out of the homogeneous, without a *force from without*, impulsive and directive.

Clerk Maxwell states the difficulty in the way of evolution from molecular science: "No theory of evolution can be formed to account for the similarity of molecules throughout all time, and throughout the whole region of the stellar universe, for evolution necessarily implies a continuous change, and the molecule is incapable of growth or decay, of preservation or destruction. . . . Therefore, for the interaction of molecules, there must be a power from without impelling and directing." Maxwell adds words which we accept: "These molecules continue this day as they were created, perfect in number, measure, and weight; and from the ineffaceable characters impressed on them we may learn that those aspirations after truth in statement and justice in action, which we reckon among our noblest attributes as men, are ours because they are the essential constituents of the image of Him who, in the beginning, created not only the heaven and the earth, but the material of which the heaven and the earth consist."

We would not deny an evolution in the physical work which Prof. Harris calls "scientic," but we would consider it with Prof. Leotze "as a gradual unfolding of a *creative spiritual* principle," and would recognize, with him and Ulrici, "in the evolution both a *mechanical* and a *teleological* process, implying both an energizing and a directing agency."

Now, if in not accepting evolution as ordinarily understood, in holding Darwinism *non-proven*, we show a limit of our intelligence and are excluded from the company of "all persons with any pretensions to education or intelligence," it positively is not from lack of study of what evolutionists have said, and certainly we have some very good company in our limitation and our exclusion; many of them are men who seem to be thoroughly conversant with *all* that has been said for evolution, and they seem to be able to grapple with the arguments.

Do not statements such as you make create a prejudice against evolution among many fair-minded men, and hinder their acceptance of its arguments?

Evolutionists repel with indignation the assertion that they are actuated by a desire to be rid of God and of moral obligation. Need they be surprised if men who have studied diligently what they say, and are yet unconvinced, do repel with equal indignation the assertion of their limitation of intelligence?

Is not the true way to grant each other the fair assumption of *honesty* and honorableness of motive and of intelligence? Is not this the *only* true way for those who would help one another in the search for the one supreme reality—TRUTH?

JOHN R. THURSTON.

WHITINSVILLE, MASS., *December* 22, 1891.

THE EARTHQUAKE OF OCTOBER, 1891, IN JAPAN.

Editor Popular Science Monthly:

SIR: In 1855, on the 11th of November, Japan was shaken by a terrible earthquake. At that time the center of the seismic disturbance was somewhere in the vicinity of

Yeddo (now Tokyo); the great part of the city was laid in ruins, and the loss of life amounted to several tens of thousands, including those who were actually crushed to death by the falling houses and those who, imprisoned in the *débris*, were burned in numerous fires which broke out in various parts of the city; for, as the earthquake occurred at about eleven o'clock at night, the inhabitants were asleep and unprepared to escape from their houses.

On the 28th of last October another part of Japan was visited by a similar catastrophe, of which more details are available than of the above-mentioned earthquake of 1855. The center of this latter seems to have been the valley of Neo, north of the city of Gifu, in the province of Mino. In this city and in the neighboring town of Ogaki the destruction is terrible and the loss of life appalling. Gifu is the seat of government of Gifu prefecture. In Gifu and Aichi prefectures the killed numbered 7,522, the wounded 9,983; the number of buildings wholly destroyed is 88,705; partly destroyed, 28,011; while throughout the entire region over which the disturbance was most seriously felt the totals are: Killed, 7,566; wounded, 10,121; buildings wholly destroyed, 89,629; partly destroyed, 28,626.

Great changes in the geographical features of the provinces of Echizen, Mino, and Owari, at the head of Owari Bay, will evidently result. Land-slips have occurred which completely changed the appearance of the mountain-sides; river channels are dammed by the *débris*, causing inundations of agricultural lands, and large lakes where were cultivated farms.

The total area throughout which the earthquake was felt is stated to have been 39,375 square miles. No serious damage was done in Tokyo or Yokohama. Asama-Yama, the volcano in the provinces of Kodzuke-Shinano, far to the north of the center of the disturbance, was thrown into a state of unusual activity, large quantities of scoriæ having been ejected. Fuji-Yama has also suffered. It appears that, ten minutes after the most violent shock, a noise like a hundred peals of thunder was heard to proceed from the side of the mountain. Some people declare that an immense land-slip, visible soon after the earthquake, has occurred; but before their statements could be verified by careful, scientific investigation, snow fell and obscured the topography.

One of the Japanese newspapers states that at the Okumstama Shrine, in the Nagajima district of Aichi prefecture, Mino province, several fissures were opened from which mud and water were ejected. After the water had drained off, a number of wooden swords, stone axes, and *maga-tama* (beads) were discovered. If this be true, it is a remarkable archæological *find*.

The trembling of earth continues up to the present time, although the shocks are no longer of destructive force. Prof. Milne, of the Imperial University, compares the rumbling sound that accompanies the shocks to that which would be produced by the escape of a great volume of steam through narrow fissures—a colossal steam-horn, in short, roaring and bellowing underground, each of its thunders indicating the explosion of a more or less destructive force.

J. KING GOODRICH.

YOKOHAMA, JAPAN, *November 16, 1891.*

COLORS OF LETTERS.

Editor Popular Science Monthly:

SIR: I was greatly interested in the article by President Jordan, on the colors of letters, which appeared recently in your magazine. From my earliest recollections I had always associated various colors with the letters, but never before have I heard of any one else who did so.

Thinking that statistics on this subject might be of interest, I send you my list of alphabet colors:

A.	Dull yellow.	N.	Tin color.
B.	Dark.	O.	
C.	Like kerosene-flame.	P.	Nearly like H.
D.	Black.	Q.	Red.
E.	Like A.	R.	Black.
F.	Dark.	S.	Silver color.
G.	Gray.	T.	Dark.
H.	Slate color.	U.	
I.	Black.	V.	Like J.
J.	Dirty brown.	W.	
K.	Black.	X.	Red.
L.	Black.	Y.	
M.	Dark red.	Z.	Red.

Those left blank are associated in my mind with a color, but I am unable to define it; and certain of the descriptions used do not fully convey the idea.

It has been suggested to me that my connecting color with the letters arose from the colors on the blocks from which I learned them. This might account for red, black, and white, but certainly would not account for the other shades.

My own explanation of the matter is this: When we are learning to spell we associate certain letters with certain words, and those words give us the idea of color. These words may be said to be *chromopoetic*, and this property, if it may be so called, can not be dissociated from them. For illustration, D is associated in my mind with dog, and when I think of dog it never is a white dog, but always a black one; hence, D is black. I brings up ink and black ink; J, a jug of brown color; V is a vulture, which I always think of as brown.

In many cases I am unable to trace the connection between the letter and the color, but I feel sure it exists somewhere in my mind. If this possesses sufficient interest to your readers to warrant its publication, you are at liberty to do so.

JAMES S. STEVENS, Professor of Physics.

MAINE STATE COLLEGE, ORONO, ME., *Aug. 15, 1891.*

EDITOR'S TABLE.

EDUCATION AND ETHICS.

ONE of the most serious questions of the present day is as to where and how adequate moral instruction is to be imparted to the rising generation. In the olden time there was no question as to the full responsibility of the home aided by the Church for the moral training of the child. School education was obtained with more or less difficulty, and, when a child was sent to school, the connection between school and home was close. The parent paid for the teaching, and master and parent worked as a general thing on the same moral lines. Nowadays, owing to the vast extension of popular education through the agency of the State, and the abolition of all direct payment of school fees, there is a severance of the former relation between home and school, and the moral interests of the children seem to be slipping to the ground between two stools. The State takes from the parent nearly all initiative in regard to the education of the child, and does so much that the parent is easily led to imagine that it does everything—that it teaches the principles of right conduct no less than the rules of grammar and arithmetic, and practices the young in virtue as systematically as in handwriting. How far this is from being really the case any one can learn on inquiry; but the vague assumption that it is the case, or ought to be the case if it is not, does a great deal, we are persuaded, to diminish the sense of parental responsibility.

From the side of religion many protests have been made against the present system of popular education. The clergy of the different churches can not help thinking that at least the more important doctrines of the Christian faith should be officially taught; and they draw most discouraging pictures of what the moral future of the youth of this country will be if their counsels are not heeded. All sound and successful moral teaching, they contend, must repose upon a basis of theology, and to confine ethical teaching to the region of the natural is to deprive it of all warrant, of all authority, of all coercive power. If these views were correct, it would be difficult to see how the weakness of our schools on the moral side could ever be remedied; for nothing is more certain than that any attempt to teach theology in them would be predestined failure. The people (or some people) will pay for theology in the pulpit, but they are not willing to pay for it in the schools, and have shown in most unmistakable ways that they do not want it there. The question, then, is: Shall all attempts at moral teaching in the public school be abandoned, seeing that it can not be administered as an adjunct of theology; or shall a brave effort be made to give it an independent status of its own and a fair chance to show what it can accomplish when conducted on purely natural lines? The latter is the decision that some earnest minds have come to, and we have at this moment before us a book produced for the express purpose of aiding the good cause. This work, published by Messrs. Houghton, Mifflin & Co., bears the title Conduct considered as a Fine Art, and consists of two essays written in response to a call from the American Secular Union for "the best essay, treatise, or manual adapted to aid and assist teachers in our free public schools . . . to thoroughly instruct children and youth in the purest principles of morality without inculcating religious doctrine." Mr. N. P. Gilman, who writes the first half of the book, and whose essay bears the special title of The Laws of Daily Conduct, shows very plainly how unnecessary it is in dealing with children to do more than illustrate

moral principles from the experience of daily life. Children do not call for metaphysics; and to refrain from teaching them the principles of morals because you are not prepared to discuss with them those ultimate questions as to the final sanction of morality which are debated by philosophers and theologians, is like withholding from a builder all knowledge of the practical applications of geometry, because you can not carry him into the calculus, or make him feel at home in the fourth dimension. Mr. Gilman states his position very well in the following passage: "When, then, we have in mind, as a subject for public school instruction, not the science of ethics, not the speculations of moral philosophers, but the orderly presentation of the common facts and laws of the moral life which no one disputes, we perceive how the religious or theological difficulty disappears to a large degree. . . . Let the relation of religion and morality be as it may be, the teacher is not called upon to decide an issue of this magnitude. He can teach the duties of ordinary life, showing their reasonableness and their interdependence in a consecutive, orderly manner, without appealing to religion; he can use the plain and usual consequences of actions good or bad without being open to a just accusation of irreligion. These consequences are admitted by all. He has then a right in reason to stop with them, because of the practical limitations imposed upon him by the time at his disposal, the immaturity of the faculties which he is training, and, most of all, because of the wide difference of men's minds as to the final explanation."

Mr. Gilman makes due allowance for the fact that a well-ordered school has "a necessary moral discipline of its own, which is enforced by every capable teacher"; but he does not think that this should be regarded as a sufficient substitute for all direct moral teaching. He considers that the school has some special advantages for effective ethical teaching which the home does not possess, and that a teacher throws away very valuable opportunities who does not find frequent occasion for bringing home moral lessons to the minds of his pupils. In this we wholly agree with him. The teacher has what the parent has not, an ever-present and more or less numerous body of hearers, to whose common judgment he can appeal; and he has the established order and discipline of the school as a means of commanding attention. Moreover, the teacher's judgment is already assumed by the child to be more or less the judgment of the outside world, whereas the parent's opinion, like his jurisdiction, is apt to be looked upon as valid only within the limits of the household. It is evident, therefore, that a vast influence for good might be exerted by the teacher, provided only he himself possessed the requisite intelligence and earnestness. The real weakness of our public schools for the purpose in view comes to light just here. Before any teacher could make a wise and effective use of such a manual as the one before us his heart would have to be in his work; he would have to possess a really apostolic zeal for the moral benefit of the children committed to his care. Are such teachers numerous? Is there anything in the conditions under which teachers are trained and selected to encourage the hope that very many of them would, under any circumstances, be earnest exponents of moral truth? We are really not aware that there is. In the vast army of public-school teachers there must be many superior minds and many noble souls; but those who have studied our school system seem to be impressed rather with the lack, than with the presence, of what we may perhaps call ethical vitality in both teachers and scholars. A teacher must outwardly bear a good character; but what examination has ever been devised to test his or her interest in ethical questions or principles, in the

stimulation of virtue or the building of character?

Still, we quite hold with those who consider that the schools ought to aim at the production of good citizens, and that, for this purpose, they should teach, with such resources as they can command, the principles of right conduct. The book before us will be useful to those who desire help in this direction. Mr. Gilman has excellent chapters on "Life under Law," "Obedience to Moral Law," "Self-control," "Truthfulness," etc., etc.; and Mr. E. P. Jackson, who contributes the second half of the book, throws his discussion of very much the same topics into the form of a series of dialogues between a teacher and his pupils. Each writer has done his work well, and the teacher who has the will to teach his or her scholars what is right will find the whole book very profitable.

We return, however, to the point with which we set out, that parental influence to-day in the moral education of children counts for too little. Mr. Gilman tells us that "numerous educators" object to giving any special instruction in morals, alleging that that is the parent's business. He might have told us, we are persuaded, from his own knowledge, that still more parents are disposed to shuffle off all responsibility for the moral education of their children on the schools. What the effect of the double disclaimer of responsibility is likely to be may readily be determined. If the clergy, instead of making futile demands for the teaching of theological dogmas in the schools, would try to rouse the minds of their adherents and followers to a sense of their personal responsibility for their children's characters, they might accomplish a more useful work. This is something which they should preach in season and out of season; and if they would do so with the earnestness which the occasion demands, the effect might in a few years be seen in the altered moral tone of a portion of the public-school teachers themselves; and thus, concurrently with the elevation of the home, we should have a notable improvement in the work of moral education as carried on in the schools. Reform the home, and the whole face of society will be reformed.

EVOLUTION AND INTELLIGENCE.

We publish in another column a letter from a correspondent who thinks that, in our article entitled Evolution and its Assailants, in the January Table, we cast a slur upon the intelligence of those who do not, in the fullest sense, accept the doctrine of evolution. The following is the statement to which our correspondent objects: "Every man within certain limits is an evolutionist, and we have little hesitation in saying that the limits within which each man is an evolutionist are the real limits of his intelligence." We hardly thought this would be misunderstood, but it evidently has been by one person at least. The word "intelligence" has two very familiar meanings. In one application it means the power a given individual has of comprehending things in general, and thus expresses a personal quality. This is the sense in which we did *not* employ the word. Again, it may mean the act or function of understanding, and this was the sense in which we *did* employ it. To say in this sense that "the limits within which each man is an evolutionist are the real limits of his intelligence," is to say that *beyond those limits he ceases to understand.* We wonder that a man who professes to be so widely read in philosophy and science as our correspondent should not have perceived that this was our meaning, and not that a man *begins to be stupid* just where he ceases to believe in evolution. The passages which our correspondent cites from some of his favorite authorities prove that we were exactly right in the position we took up, for they all go to show that, in the chain of events which make up the

history of our globe, there are some which baffle comprehension. In a certain sense evolution itself may be said to baffle comprehension, since the human intellect can never fully understand how one thing can become anything else; but the general processes of evolution are at least illustrated by facts which long and repeated experience has rendered very familiar. On the other hand, there is nothing analogous to any well-established human experience in the miraculous interference which those have to postulate who either reject evolution altogether, or only recognize it to a limited extent.

Our correspondent also objects to our statement that "all persons with any pretensions to education or intelligence believe in evolution as applied to the physical history of our globe." At the moment we were thinking more of the globe itself than of its living inhabitants; and before objecting to our statement our correspondent might properly have raised with himself the question whether we meant more than we actually said. However, on points like these there will, of course, be differences of opinion, and we must only ask our correspondent to believe that we meant no disrespect in anything that we said to persons of his way of thinking. We believe in evolution because it has already explained so many things, and because its scope as a scientific theory is continually widening. If our correspondent declines to accept it on such grounds as he alleges in his article, he is quite within his right. What he has not shown us is what phenomena or events to which the doctrine of evolution has no application he really *understands*.

LITERARY NOTICES.

MY CANADIAN JOURNAL, 1872–'78. By the MARCHIONESS OF DUFFERIN AND AVA. New York: D. Appleton & Co. Pp. 456. $2.

THE Journal consists of extracts from letters written home to the author's mother while Lord Dufferin was Governor-General of Canada. Although—the letters having been written from twelve to twenty years ago—it is rather an account of the past than a description of the present, and Canada has undergone a great development, its villages having become towns and new railways having developed cities in what was the wilderness, the Journal has lost none of its freshness; for it is the record, made on the spot and at the moment, by a keen observer of cultivated intelligence, disposed to make the best of everything that she saw and experienced; and such records are always fresh. So we are given, in the familiar style which intimate friendship authorizes, yet always graceful, sketches of travel, adventure, scenery, society, social and economical conditions, sports, more serious occupations, and whatever is of the life of the country. The pictures are of all seasons through eight years; they cover all parts of Canada, the St. Lawrence, the lakes, the Maritime Provinces, the west, northwest, and Pacific coast, and the Eastern Townships, with occasional excursions into the United States, concerning which the author is sorry to pass so lightly over the cordiality and the friendliness that were invariably shown her and her husband—"for whether we were traveling officially through Chicago or Detroit, or went as ordinary visitors to New York or Boston, we were always received with a kindness and cordiality which we can never forget."

STUDIES IN AËRODYNAMICS. By S. P. LANGLEY. Smithsonian Institution. 1891.

THIS monograph of Prof. Langley is the record of four years' experimental work with the inclined plane, to determine the conditions to be complied with in moving such a plane through the air, the power required, etc. His work has thoroughly convinced him of the practicability of moving such planes through the air with our present means of propulsion. It has generally been thought that the one essential element needed to be provided, in order to make mechanical flight possible, was an extremely light and powerful motor. But Prof. Langley's experiments have shown that we need not make a search for such a motor, as the steam-engine, in the forms we now possess it, is quite equal to the occasion. His ex-

periments have demonstrated the somewhat remarkable fact that the power required to sustain an inclined plane, when inclined at a slight angle to the horizontal and driven forward, decreases with the speed. He finds that there is a speed for any given plane at which the plane becomes self-supporting, or rather in which it tends to rise. This speed he terms the soaring speed, and when it is reached the weight becomes unimportant. With greater weights it is only necessary to drive them at greater speeds in order to eliminate the element of weight. The practical conclusion from this is that we are not prohibited by the weight of our apparatus from achieving mechanical flight, and the problems to be solved are not those connected with the question of weight, but rather those concerning the details of construction by means of which the apparatus may be controlled while under movement and in ascent and descent, so as to be safe and manageable. The method of experiment adopted by Prof. Langley consisted in mounting an inclined plane at the end of the arm of a whirling table sixty feet in diameter. This table was driven by power at such a rate that a speed of one hundred miles an hour could be attained. The plane was mounted in such a way that it was free to fall, and, by a number of ingenious appliances designed by Prof. Langley, the power which would be required to drive the plane in free air at the speeds attained could be measured. The numerical result arrived at by the experiments is that by the expenditure of one horse-power a weight of two hundred pounds can be transported through the air at the rate of forty-five miles an hour. As a steam-engine of this power can be built to weigh not more than one tenth of this amount, it will be seen that there is a wide margin between the weight of the motor and the total weight which can be moved by it. When we consider the vast practical results which would follow the successful navigation of the air, the value of experiments such as these which supply us with data necessary to a solution of the problem can not well be overestimated. It is to be hoped that Prof. Langley will be able to continue his experiments until all the problems bearing upon this interesting and important subject shall have been solved.

THE JOURNAL OF PHYSIOLOGY. Edited by MICHAEL FOSTER. Cambridge, England: Cambridge Engraving Company. Vol. XII. Price, $5 a volume.

THE editor has the co-operation in conducting this journal—the foremost one of its class—of Professors W. Rutherford and J. Burdon-Sanderson, in England, and Professors H. P. Bowditch, H. Newell-Martin, H. C. Wood, and R. H. Chittenden, in the United States. The journal is published in numbers which appear not at rigidly fixed times, but at varying intervals, determined by the supply of material. The present volume consists of five numbers, the last one of which is made up of parts five and six, and contains thirty-one articles in original experimental physiological research. These articles relate to different elements of animal organisms; to the circulation, the nervous system, the action of various substances on bodily functions and products; respiration, temperature relations, the excretions; and to apparatus. They are prepared by careful and accurate experimenters, many of whom are experts or physiologists of world-wide reputation, and record in minute detail what they have themselves observed; the observations being usually accompanied by charts showing the graphic records made by the instruments used.

A POPULAR HAND-BOOK OF THE ORNITHOLOGY OF THE UNITED STATES AND CANADA. Based on Nuttall's Manual. By MONTAGUE CHAMBERLAIN. Boston: Little, Brown & Co. Two volumes. Pp. xlvii+473, and vii+431. Price, $8.

THE first volume of Nuttall's Manual was published in 1832, and the second in 1834. The book was the work of a master of the ornithological knowledge of the day, and of an author who commanded a warm literary style with fine powers of description. It was the first hand-book of the subject that had been published, and was carried at once into favor, not less by its innate qualities than by the interest of the subject. While a great advance has been made in scientific or technical ornithology, the study of bird-life, the real history of our birds, remains just about where Nuttall and his contemporaries left it. We have brilliant and engaging essays on various aspects of it by such writers as Bradford Torrey, Mrs. Miller, and

Frank Bolles; but they do not appear in the hand-books, and, as Mr. Chamberlain remarks, "in comparison with the work accomplished by the older writers, and with that which is still unknown, the recent acquisitions must be considered slight." Nuttall's work has been out of print for several years; but its popularity and real value have kept it in demand, and the few copies recently offered for sale were disposed of at high prices. In publishing the new edition instead of issuing it in the form of the original, or remodeling it to the extent that would be required to arrange it in harmony with the new system in ornithology, the editor has reproduced Nuttall's biographies with few changes beyond pruning them of what was obsolete; has added, in notes distinguished by smaller type, such new facts as seemed needed to bring the descriptions into conformity with the present state of the science; has rewritten the descriptions of plumage, endeavoring to phrase them in well-known and untechnical terms, so that they may be understood by unskilled readers; and has added a description of the nest and eggs of each species. The untechnical character of the work, and the use of simple, well-known terms in the descriptions, are a feature on which the publishers speak with some pride. Canadian readers have been kept in mind, and accounts are given of every species that has been found within the Dominion east of the Manitoba plains, and of their Canadian distribution. The editor is a specialist in ornithology, on which he has published numerous articles in periodicals devoted to the science and monographs. We were interested in reading Nuttall's introduction, which is given entire and unchanged, a foreshadowing of the doctrine of protective mimicry which has been made prominent by Mr A. R. Wallace. Some birds, it is observed, "are screened from the attacks of their enemies by an arrangement of colors assimilated to the places which they most frequent for subsistence and repose; thus the wryneck is scarcely to be distinguished from the tree on which it seeks its food; or the snipe from the soft and springy ground which it frequents. The great plover finds its chief security in stony places, to which its colors are so nicely adapted that the most exact observer may be deceived. The same resort is taken advantage of by the night-hawk, partridge, plover, and the American quail the young brood of which squat on the ground, instinctively conscious of being nearly invisible, from their close resemblance to the broken ground on which they lie, and trust to this natural concealment. The same kind of deceptive and protecting artifice is often employed by birds to conceal or render the appearance of their nests ambiguous. Thus the European wren forms its nest externally of hay, if against a hay-rick; covered with lichens, if the tree chosen is so clad; or made of green moss, when the decayed trunk in which it is built is thus covered; and then, wholly closing it above, leaves a concealed entry in the side. Our humming-bird, by external patches of lichen, gives her nest the appearance of a moss-grown knot. A similar artifice is adopted by our yellow-breasted fly-catcher, or vireo, and others." The first volume is devoted to land birds, the second to game and water birds. The accounts are confined to birds known east of the Mississippi Valley. The work is published in beautiful style, with pictorial illustrations that it would be hard to excel of most of the species, and a colored plate in each volume.

CHRISTIANITY AND INFALLIBILITY: BOTH OR NEITHER. By the Rev. DANIEL LYONS. New York: Longmans, Green & Co. Pp. 284. Price, $1.50.

THIS book bears the *nihil obstat* (no objection) of D. Pantanella, S. J., and the imprimatur of the Roman Catholic Bishop of Denver. It was written under the influence of the conviction which the author believes the logic of facts is daily confirming, that "Christianity, to maintain its rightful hold on the reason and conscience of men, needs a living, infallible witness to its truths and principles; a living, infallible guardian of its purity and integrity, and a living, infallible interpreter of its meaning." The doctrine of infallibility, he believes, "goes to the very root of the Christian controversy, and supplies the only complete and satisfactory solution of the many and grave difficulties which it involves." Grant it, and in it "you have a ready, easy, and at the same time a perfectly satisfactory solution of the religious controversy with all its difficulties. Reject

the doctrine of infallibility, and your path, as a believer in Christianity, is beset with insuperable difficulties." Protestants, it appears, have very erroneous conceptions of the meaning of this doctrine, which if they were correct would rightfully condemn it. As defined by the author, its true meaning is that "the Pope, by virtue of a special supernatural assistance of the Holy Spirit of Truth promised to him, in and through St. Peter, is exempt from all liability to err when, in the discharge of his Apostolic Office of Supreme Teacher of the Universal Church, he defines or declares, in matters of or appertaining to Christian faith or morals, what is to be believed and held, or what is to be rejected and condemned by the faithful throughout the world." Besides the meaning of infallibility, which is thus summarized, the author considers the reasons why Catholics believe in the dogma of infallibility, the way they meet the objections to it, and—in the appendixes—The Happiness of Converts, Some Facts relating to the Vatican Council, and Pontifical Decrees and the Obedience due to them.

THE TWO REPUBLICS; OR, ROME AND THE UNITED STATES OF AMERICA. By ALONZO T. JONES. Battle Creek, Mich.: Review and Herald Publishing Co. Pp. 895. Price, $2.50.

THE purpose of this book is to study the interrelationship of government and religion, in respect to which Rome and the United States are regarded as occupying the two extremes. "The principle of Rome in all its phases is that religion and government are inseparable; the principle of the Government of the United States is that religion is essentially distinct and totally separate from civil government, and entirely exempt from its cognizance. The principle of Rome is the abject slavery of the mind; the principle of the United States of America is the absolute freedom of the mind. As it was Christianity that first and always antagonized this governmental principle of Rome, and established the governmental principle of the United States of America, the fundamental idea, the one thread-thought of the book, is to develop the principles of Christianity with reference to civil government, and to portray the mischievous consequences of the least departure from those principles." All Sunday legislation is so strenuously opposed, that this may be regarded as the chief purpose of the book. The Rome that is treated of is that which was brought into relation with Christianity, the empire, and the papacy. The persecutions of the Christians, which are regarded as simply the legitimate outcome of the impartial enforcement of the laws when inflicted by good emperors, and as a part of their undiscriminating viciousness when inflicted by bad ones, are considered the legitimate results of the union of Church and State. As Christianity became stronger, it is charged with having adopted heathen features as a means of making its way more rapidly—"the great apostasy"—and particularly those connected with the worship of the sun (which is supposed to be, of all pagan cults, the most abhorrent to Jehovah), and among them the consecration of Sunday. The growth of other features held to be in conflict with pure religion and freedom is traced through the lives of emperors and popes. The transplantation of some of them, even after the Reformation, to America, and their gradual elimination under the workings of our free institutions; and the efforts, in recent years, by the National Reform Union, the Sabbath Union, and other societies, to secure the incorporation in the Constitution of a recognition of the Christian religion, and the enforcement of Sabbath laws, are successively reviewed. "As surely," the author concludes, "as the movement to commit the Government of the United States to a course of religious legislation shall succeed, so surely will there be repeated the history of Rome in the fourth and fifth centuries," and our republic will "be led captive in the ruinous triumph of the papacy."

THE POSITIVE THEORY OF CAPITAL. By EUGEN V. BÖHM-BAWERK. Translated, with a Preface and Analysis, by WILLIAM SMART, M. A. London: Macmillan & Co. 1891. Pp. 428. Price, $4.

IN this volume Prof. Böhm-Bawerk deals with one of the vexed questions of economics—the economic basis of interest—with the question why the lender of a sum of money, for instance, should demand at the end of the period for which it is lent, not only the original sum, but a bonus as well.

The different theories which have been

advanced by economists to account for interest have been reviewed and subjected to criticism by the author in his previous work, Capital and Interest. This destructive criticism he now follows by a positive construction of his own, in which he seeks to find a lasting basis for the phenomenon of interest, in a theory which does not necessitate the resort to questionable hypotheses to support it. This basis he finds in considering interest, not as a bonus paid for the use of capital, but as a surplus arising from the greater value of present goods over future ones. He regards the transaction, say, of the loan of a sum of money and the payment of interest for it, as a case of the exchange of goods—the exchange of present goods for future ones.

As present goods are more desirable than future ones of the same face value, they command a premium, and this premium is interest. The following extract from the author's discussion of the sources of interest sets forth clearly his own views, as well as his estimate of previous explanations:

"In the previous book I have tried to show, and account for, the natural difference that exists between the value of present and the value of future goods. I have now to show that this difference of value is the source and origin of all interest on capital. But, as the exchange of present commodities for future commodities takes various forms, the phenomenal forms of interest are as various, and our inquiry must necessarily deal with them all. In the following chapters, therefore, I intend to take up, in succession, all the principal forms of interest, and I shall endeavor to show that, notwithstanding all differences in shape and appearance, the active cause in them all is one and the same—namely, the difference in value between present and future goods.

"By far the simplest case of this difference in value is presented in the loan. A loan is nothing else than a real and true exchange of present goods for future goods; indeed, it is the simplest conceivable phenomenal form, and, to some extent, the ideal and type of such an exchange. The 'lender,' A, gives to the 'borrower,' B, a sum of present goods—say present pounds sterling. B gets full and free possession of the goods, to deal with as he likes, and, as equivalent, he gives into A's full and free possession a sum of entirely similar, but future, goods—say, next year's pounds sterling. Here, then, is a mutual transfer of property in two sums of goods, of which one is given as recompense or payment for the other. Between them there is perfect homogeneity, but for the fact that the one belongs to the present, the other to the future. I can not imagine how an exchange in general, and an exchange between present and future goods in particular, could be expressed more simply and clearly. Now, in the last chapter we proved that the resultant of the subjective valuations which determines the market price of present and future goods is, as a rule, in favor of present goods. The borrower, therefore, will, as a rule, purchase the money which he receives now by a larger sum of money which he gives later. He must then pay an 'agio' or premium (*Aufgeld*), and this agio is interest. Interest, then, comes, in the most direct way, from the difference in value between present and future goods.

"This is the extremely simple explanation of a transaction which, for hundreds of years, was made the subject of interpretations very involved, very far-fetched, and very untrue."

Prof. Böhm-Bawerk considers the profit of capitalist undertakings as a case of interest, and explainable by his formula, on the ground that the "owners of capital are merchants in present goods, such goods being more valuable than the "future goods"—labor, uses of land, and capital—which the capitalist buys. While this work is primarily addressed to economists, it is quite within the range of the general reader who is interested in economic questions.

ELECTRICITY AND MAGNETISM. Translated from the French of AMÉDÉE GUILLEMIN. Revised and edited by SILVANUS P. THOMPSON. Macmillan & Co. 1891. Pp. 967. Price, $8.

THE industrial applications of electricity have been so many and so varied, and they have increased at so great a rate in recent years, that the subject of the uses and possibilities of this marvelous agent possesses an interest for the general public shared by none of the other great agencies which have contributed so largely to our material advancement. This interest has been both sustained and augmented by the many popu-

lar expositions which have appeared in recent years, in which the principles of the science and their application to the arts have been told in plain, simple, and attractive language. Already the popular literature of the subject is large, and keeps pace with the advance in industrial and technical uses. Of recent contributions of this character the work of M. Guillemin is one of the most notable. The work covers a general exposition of the science of electricity and magnetism, and then brief and concise descriptions of apparatus and appliances. In the division devoted to the industrial applications, the subjects considered are—the mariner's compass, lightning-conductors, telegraphy, the telephone, microphone, and the radiophone, electric clock-work, motors, transmission of power, electric lighting, electro-plating, and various minor applications. In an appendix Prof. Thompson gives a brief account of the modern views of the nature of electricity, based upon the researches of Faraday and Maxwell.

The book is handsomely got up, printed in large type, on heavy calendered paper, with wide margins, and is very fully illustrated.

MENTAL SUGGESTION. By Dr. J. OCHOROWICZ, with a Preface by CHARLES RICHET. New York: The Humboldt Publishing Company. Pp. 361. Price, $2.

AS we gather from the concluding chapter of this work, by mental suggestion is meant a "dynamic correlate" sent forth by thoughts in every direction. Thoughts do not travel; "no substance is carried hither or thither, but a wave is propagated and modified more and more according to the different natures and the different resistances of the media it traverses." It is mental action at a distance, upon subjects which have to be in a proper *rapport* or relation to the acting thought. By it the phenomena of hypnotism, occultism, which it does not favor but banishes, and kindred mysteries are supposed to be accounted for. According to Dr. Richet's interpretation, the theory means that "independently of any phenomenon appreciable by our normal senses or by our normal perspicacity, how quick soever it may be supposed to be, there exists between the thought of two individuals a correlation such as chance can not account for." Dr. Ochorowicz sets forth a multitude of facts which have been observed by himself and by sundry experimenters, criticises them vigorously and seeks to eliminate the difficulties that might arise from fraud or chance, and to present the conclusions which seem to be established. Yet Dr. Richet does not maintain that his argument produces conviction, but only doubt. "So strong in its action upon our ideas is the influence of routine and of habit," which have taught us to ignore the conclusions to which the phenomena would lead an unprejudiced mind. "But," Dr. Richet adds, "whatever the opinion ultimately formed as to the reality of mental suggestion, it ought not, I think, to influence one's judgment as to M. Ochorowicz's book. Everybody, it seems to me, must recognize his sincerity, his perseverance, and his contempt for ready-made opinions. One feels that he has a passionate love of truth." The body of the work consists largely of citations of incidents apparently or really illustrating the doctrine of mental suggestion, with the author's criticisms and comments upon them, and the conclusions drawn from them.

SOLUTIONS. By W. OSTWALD. Translated by M. M. PATTISON MUIR. London and New York: Longmans, Green & Co. Pp. 316. Price, $3.

THE volume here offered to chemists is a portion of the author's Lehrbuch der allgemeinen Chemie, a second edition of which was issued toward the end of 1890. Sufficient reason for its translation and publication by itself is given in the appearance and rapid growth during the last three or four years of van 't Hoff's theory of solutions. An authoritative statement of this theory, together with a systematic setting forth of the great mass of facts about solutions that have been accumulated, has obvious value for chemists at the present time. The eminent rank of the translator among English chemists, together with the fact that he has had the co-operation of the author in preparing this version, insures that the treatise has lost nothing in the process of translation. It has, in fact, gained the benefit of some slight revisions, and some additions from memoirs published in the first half of 1891.

THE PRACTICAL TELEPHONE HAND-BOOK. By JOSEPH POOLE New York: Macmillan & Co. Pp. 288. Price, 75 cents.

THE task which the author of this hand-book has performed is a presentation of the art of communication by telephone as it is now practiced. To this end he describes the batteries, receivers, transmitters, signaling apparatus, and switch-boards in general use, the systems employed in operating telephone exchanges, modes of constructing telephone lines, together with the poles, wires, insulators, and other material required in the construction. Long-distance working is also treated, and underground work and the localization of faults are not omitted, while a few minor or very recent topics are included in a miscellaneous chapter and an appendix. The volume is a thoroughly practical one and is fully illustrated.

MODERN AMERICAN METHODS OF COPPER-SMELTING. By EDWARD DYER PETERS, M. E., M. D. Second edition, revised and enlarged. New York: The Scientific Publishing Company. Pp 398.

THE author has dealt most largely in this work on facts gleaned from his own experience, while he has aimed to touch upon theoretical questions only when it was essential for the understanding of practical facts. Much attention has been given to matters of cost, both of construction and subsequent operation, and in this expenses are given, not as calculated on paper, but as actually incurred in building on a large scale and in smelting many thousand tons of ores under various circumstances, and in all the ordinary kinds of furnaces. The first edition of the book was published in 1887. For the second edition such new material as time and experience have suggested has been added. But the advances in copper-smelting since the work first appeared have been rather in a general enlargement of furnaces and apparatus than in any radical changes or inventions. A section on the electrolytic assay of copper has been prepared by Mr. Francis L. Sperry, of Sudbury, Ontario, and information and plans of the regenerative gas-furnaces used at Atvidaberg, Sweden, have been furnished by Mr. Paul Johnson. It is in these regenerative gas-furnaces that the author expects to see realized the vital point of economy in the use of fuel. In the first chapter the ores of copper are described; in the second, their distribution is pointed out. The chapters that follow concern methods of copper assaying, the roasting of copper ores in lump form, stall roasting, roasting in lump form in kilns, calcination of ore and matte in a finely divided condition, the chemistry of the calcining process, smelting, blast-furnaces, the smelting of pyritous ores containing copper and nickel, reverberatory furnaces, refinement of copper with gas in Sweden, treatment of gold and silver bearing copper ores, and the Bessemerizing of copper mattes.

A GRADUATED COURSE OF NATURAL SCIENCE. By BENJAMIN LOEWY, F. R. A. S., etc. Part II. London and New York: Macmillan & Co. Pp. 257. Price, 60 cents.

THE second installment of this course of study consists wholly of experiments, most of them being in the domain of physics, but some in that of chemistry. The elementary laws and principles of mechanics, acoustics, optics, and electricity are successively brought out, and a few forms of chemical action are illustrated. A list of questions is given on the work included in each chapter. This part of the course is designed for young students, hence the directions and interpretations of the experiments are given in simple language. An appendix contains hints for performing the experiments, and there are sixty diagrams of apparatus in the body of the book. The author states that he has throughout aimed at rendering the experiments feasible with a very limited apparatus, and inexpensive materials and appliances.

ELECTRICITY SIMPLIFIED. By T. O'CONOR SLOANE. New York: Norman W. Henley & Co. Pp. 158. Price, $1.

THE objects of this little book are to explain the commonly accepted theory in regard to the action of electricity, and to describe the various ways in which electrical energy has been practically utilized. The theoretical part of the subject most needs explanation, and hence naturally receives most attention. Among the practical questions of popular interest that are answered are, How long does it take to send a signal

across the Atlantic Ocean? how are cars on electric railroads worked? and under what conditions can a fatal shock of electricity be received? The text is illustrated with twenty-nine figures.

THE STORY OF OUR CONTINENT. By N. S. SHALER. Boston: Ginn & Co. Pp. 290. Price, 85 cents.

THE study of the ordinary text-books on geography gives pupils a minute acquaintance with the features of each division of a country, but leaves them without any broad view of the country as a whole, and without any appreciation of the relations of one section to another. This lack with respect to North America Prof. Shaler has aimed to supply by means of a reader in geography and geology telling how this continent grew into its present form, what aboriginal peoples are known to have inhabited North America, how the form of the continent has affected the history of its several groups of colonists, and what are its resources and commercial condition. Comparisons with some features of the Eastern Continent are introduced in the course of the description. The volume is illustrated and has an index.

Part XIX (July, 1891) of the *Proceedings of the Society for Psychical Research* contains three principal papers, all of which embody reports, confirmed by several witnesses, of so-called psychic phenomena. The first paper, by Mr. F. W. H. Myers, is On Alleged Movements of Objects, without Contact, occurring not in the Presence of a Paid Medium. These movements include the rising of tables from the floor, knockings, ringing of bells, writing on slates, and the moving of chairs and various smaller articles. A record of Experiments in Clairvoyance is contributed by Dr. Alfred Backman, of Kalmar, Sweden. The cases given include seeing ordinary actions at a distance, describing a murderer and his house, describing Christmas presents some days before Christmas that the King of Sweden was to receive, and finding a miniature revolver that had been lost in a field. Dr. Richard Hodgson describes A Case of Double Consciousness occurring in a preacher named Bourne, living in Rhode Island. Mr. Bourne wandered from his home in 1887 and set up a small store in Norristown, Pa., which he kept for six weeks before recovering his identity. Mr. Bourne has been several times hypnotized and questioned by Dr. Hodgson, Prof. James, and Dr. Morton Prince. A supplement contains a Third *ad interim* Report on the Census of Hallucinations, covering returns received in England and in France, a reply to Mr. A. R. Wallace on Spirit Photographs, by Mrs. Henry Sidgwick, and two notices of books. Dr. Richard Hodgson, 5 Boylston Place, Boston, is the agent of the society in America.

A laboratory manual has been published by Prof. *Delos Fall*, of Albion, Mich., under the title *An Introduction to Qualitative Chemical Analysis*. It is intended to lead students to learn analysis by the inductive method. That this method of study "produces strong, accurate, enthusiastic, and independent students" is attested by the author's experience of several years with it. An introduction contains an outline of the mode of teaching for which the book is adapted; the tests are interspersed with practical hints and with questions that draw the student's attention to the essential features of what he is doing; lists of apparatus and reagents required are given, and also forms for recording the results, which to the student are discoveries.

The Legislature of the new State of Wyoming, in January, 1891, established the *Wyoming Experimental Station*, which, under date of May, 1891, issued its first *Bulletin*. This document describes the organization and the proposed work of the station. The arrangements for agricultural experiments include six farms, at altitudes from four thousand to seven thousand feet above sea-level, four fifths of the State being between four thousand and eight thousand feet. All but one of these farms are under irrigation. Special experiments on grasses are also being carried on under the direction of the U. S. Department of Agriculture.

Bulletin No. 33, New Series, of the *New York Agricultural Experiment Station* is devoted to fertilizers. It contains one paper that can not be too highly praised; this is an Explanation of Terms of Chemical Analysis. A great part of the literature of agricultural stations is made entirely useless for the farmers that are taxed to pay for it by the use of chemical and other technical

phraseology that only graduates of scientific schools can understand. Such explanations as the above should be multiplied.

A pamphlet with the title *Ethereal Matter; Electricity and Akasa*, has been made by *Nils Kolkin*, consisting of extracts from two books by the same author (J. M. Pinckney Co., Sioux City, Iowa, fifty cents). The subjects treated are the less known forces of Nature and various hypothetical substances, and the pamphlet will doubtless have interest for those who enjoy excursions into the unexplored domain of physics.

A stirring and practical address on *The Teacher as he should be*, delivered by *C. W. Bardeen* in July, 1891, has been published in a pamphlet (Bardeen, Syracuse, N. Y.). The drift of the address is that personality is of far more importance in a teacher than pedantically accurate knowledge on every subject.

A weekly magazine, called *Railway Law and Legislation*, and conducted by *W. P. Canaday* and *G. B. West*, began to appear in September, 1891 (712 Tenth Street, N. W., Washington, D. C., $3 a year). It is concerned with legislation, litigation, and financial and economic developments affecting common carriers. The first article is a historical sketch of The Nicaragua Canal Project. Other subjects treated are Canadian Competition and Discrimination, The Postal Telegraph Bill, The Coming Committees (a forecast), and rious minor matters mentioned in notes.

Among the Miscellaneous Documents of the Fifty-first Congress was one entitled *Postal Savings-Banks; an Argument in their Favor by the Postmaster-General.* The reasons for adding the function of savings-banks to the post-offices are set forth in a communication of fifteen pages, and an appendix of seventy-two pages contains a proposed bill to establish postal savings-banks, details of such systems of banks in other countries, opinions of previous postmasters-general, a large number of press comments concerning postal savings-banks, and some minor exhibits.

The first number of a quarterly magazine, devoted to matters of interest to inhabitants of Kansas, was published at Salina, Kan., July, 1891 (C. B. Kirtland Publishing Company, $1 a year). It is called *The Agora*, and the contents of its first number include The Kansas "Mulligrub," by Hon. William A. Phillips; Imagination in Science, by Prof. L. E. Sayre; A New Sociology, by Rev. E. C. Ray, D. D.; "Bleeding Kansas," by Prof. J. W. D. Anderson; besides other articles, poetry, and book notices.

An Introductory French Reader, the object of which is to prepare the pupil in the shortest possible time to read French easily, has been prepared by *William Dwight Whitney* and *M. P. Whitney*, and is published by Henry Holt & Co. and F. W. Christern. The exercises have been selected, with this end in view, from the works of the best-known French authors, choosing such passages as are simple enough to present little difficulty in translation, and so varied and interesting as to rouse and hold attention. A full vocabulary, in which the ordinary idiomatic phrases and expressions in the text are explained, and a table of irregular verbs are added; while the grammatical difficulties and a few literary and historical points are treated in the notes. (Price, 70 cents.)

The A B C of the Swedish System of Educational Gymnastics is a practical handbook for teaching the subject, prepared by *Hartvig Nissen*, an experienced teacher of the exercise in the public schools of Boston, and published by F. A. Davis, Philadelphia. The first two chapters contain such questions as have been frequently put to the author, the answers to which give a satisfactory idea of the foundation of the system. Other chapters contain prescriptions for daily lessons, arranged for school classes of different grades. Full instructions and commands are given for each lesson, and the whole is illustrated by seventy-seven engravings. (Price, 75 cents.)

Mr. *Thomas Bertrand Bronson's* little manual of *Colloquial German* is designed to be a drill-book in conversation for school classes or self-instruction, and is intended to offer in convenient form a short course in that art and in German composition. It contains exercises in ordinary English conversation, which the student is expected to turn into German, to aid him in doing which a vocabulary, a summary of grammar, and a list of the irregular verbs are added. (Published by Henry Holt & Co. Price, 65 cents.)

PUBLICATIONS RECEIVED.

Annual Report of the Postmaster-General. Government Printing-Office. Pp. 183. With Maps.

Bacteriological World. Paul Paquin and J. H. Kellogg, editors. Battle Creek, Mich. Monthly. Pp. 40. $2 a year, 25 cents a number.

Bolton, H. C. Scientific Correspondence of Joseph Priestley. Pp. 240. With Portrait.

Butler, Amos W. The Birds of Indiana. Pp. 135.

Calendar for 1892. Styles & Cash. New York.

Carus, Paul. Homilies of Science. Chicago: Open Court Publishing Co. Pp. 317. $1.50.

Chaddock, C. G. Visual Imagery of Alcoholic Delirium. Pp. 5. Reprint.

Commissioner of Labor. Annual Report for 1890. Parts I, II, and III. Government Printing-Office.

Cornell University Agricultural Experiment Station. Bulletin 33. Wire-worms. Pp. 82.

Engineering and Mining Journal. Mineral Statistics for 1891. New York: Scientific Publishing Co. Pp. 78.

Geikie, Archibald. Geological Sketches at Home and Abroad. New York: Macmillan & Co. Pp. 332. $1.50.

Green, C. H. Catalogue of a Unique Collection of Cliff-dweller Relics. Chicago. Pp. 35. 25 cents.

Hart, A. B. Epoch Maps illustrating American History. New York: Longmans, Green & Co.

Humanity and Health. Monthly. New York: Humanity Publishing Co. Pp. 14. $1 a year, 10 cents a number.

Hunt, T. Sterry. Systematic Mineralogy based on a Natural Classification. New York: Scientific Publishing Co. Pp. 391. $5.

Hutchinson, Rev. H. N. The Story of the Hills. New York: Macmillan & Co. Pp. 357. $1.50.

Keller, Helen. Souvenir of the First Summer Meeting of the American Association to promote the Teaching of Speech to the Deaf. Washington: Volta Bureau. Illustrated.

Langley, S. P. Report of the Secretary of the Smithsonian Institution. Government Printing-Office. Pp. 63.

Lethaby, W. R. Architecture, Mysticism, and Myth. New York: Macmillan & Co. Pp. 272. $1.75.

Martin, G. H. Antidotes to Superstition. London: Watts & Co. Pp. 154.

New York State Reformatory. Sixteenth Yearbook. Illustrated.

New York and the World's Fair. Pp. 50. Illustrated.

Peirce, Dr. C. N. Sanitary Disposal of the Dead. Philadelphia Cremation Society. Pp. 57.

Philosophical Review. Bimonthly. J. G. Schurman, Editor. Boston: Ginn & Co. Pp. 128. 75 cents a number, $3 a year.

Porter, Robert P. The Eleventh Census. New York: Engraving & Printing Co. Pp. 64.

Powell, J. W. Tenth Annual Report of the United States Geological Survey. 2 vols. Pp. 123 and 774. Government Printing-Office. Illustrated.

Report of Board of Engineer Officers, United States Navy, on Ward's Water-tube Marine Boiler, etc. Pp. 32. Illustrated.

Roads Improvement. Papers by Isaac B. Potter, Edward P. North, and Prof. Lewis M. Haupt. Pp. 30. Reprint.

School and College. Ray Greene Huling, Editor. Boston: Ginn & Co. Monthly. Pp. 64. 20 cents a number, $1.50 a year.

School of Applied Ethics. First Year's Work. Pp. 15.

Scott, Alexander. Introduction to Chemical Theory. London: Adam and Charles Black. Pp. 266. $1.25.

Shufeldt, R. W. Where Young Amateur Photographers can be of Assistance to Science. Pp. 5. Reprint. Illustrated.

Smithsonian Institution. Miscellaneous Papers. Some Observations on the Hevasu Pai Indians and The Navajo Belt-weaver. By R. W. Shufeldt.—On the Characters of some Palæozoic Fishes. By E. D. Cope.—Condition and Progress of the United States National Museum. By G. Brown Goode.—The Genus Panopeus. By James A. Benedict and Mary J. Rathbun.—The Pito te henua, or Easter Island. By William J. Thompson.—Aboriginal Skin-dressing. By Otis T. Mason.—Animals recently Extinct, etc. By Frederic A. Lucas.—The Development of the American Rail and Track. By J. Elfreth Watkins.—Department of Geology. United States National Museum. By George P. Merrill. Government Printing-Office, 1891.

Statistics of Railways. Part of Third Annual Report to the Interstate Commerce Commission. Government Printing-Office, 1891. Pp. 99. Advance sheets.

Texas Sanitarian. T. J. Bennett, Editor. Monthly. Austin, Texas: Sanitarian Publishing Co. Pp. 72. $2 a year.

Thornton, C. S. Report on the Condition of the Cook County Normal School. Chicago. Pp. 27.

Trimble, Henry. The Tannins. Philadelphia: J. B. Lippincott Co. Pp. 168. $2.

United States Geological Survey Bulletins No. 62, 65, 67 to 81, inclusive. Government Printing-Office, 1890 and 1891.

Wright, G. Frederick. Theory of an Interglacial Submergence in England. Pp. 8. Reprint.

Wyatt, Francis. The Phosphates of America. New York: Scientific Publishing Co. Pp. 187. $4.

POPULAR MISCELLANY.

A Defense of Examinations.—Examinations are defended by W. H. Maxwell, in a paper which he read before the National Education Association at its meeting in 1890. To the question, "Is examination one of the means that occasion those mental activities which result in knowledge, power, and skill?" Mr. Maxwell gives an affirmative answer, saying: "Knowledge is not knowledge when it has been merely taken in. It is not knowledge until it has passed through the mind and come out again in words or actions of our own. Until this is done, we can not be sure even that we possess knowledge. Every thorough-going student has been at some time or other, when confronted with examination questions, amazed at his own ignorance of subjects with which he fondly imagined he was thoroughly familiar. There is probably no better test of a teacher's ability than his power to determine, during the giving of a lesson or after it has been given, whether it has been mastered by his pupils. And yet I have frequently seen teachers of great ability astonished at their pupils' ignorance of subjects which they (the teachers) thought had been completely

mastered. In all these cases the examination test proves that the knowledge in question has not been assimilated, has not been converted into faculty. The very act of reproducing knowledge in the pupil's own words or acts is one of the best means of converting it into faculty; but it is not the only means. The process is not complete when isolated facts, nor even when divisions of a subject, have passed through the mind and been reproduced. All this is necessary, but it is not enough. It is but a means to an end, and the end is the comprehension of a subject as a whole, and the comprehension of the relations of the various parts to one another and to the whole. . . . Nor is even this all. The process of learning is not complete till the pupil can apply his knowledge in some practical way. . . . Examination consists not merely in reproducing knowledge imparted or acquired, but in making practical application of knowledge, in testing power and skill. And hence on this ground also—the ground of practical application as well as that of reproduction—examination, seeing that it is not only a test of application and reproduction, but an exercise in application and a means of the development of power and skill, must be regarded as an element of teaching what is good."

Climate and Health.—The modifying effects of differences in age deserve more attention than they have received in the discussion of the influence of climate upon health. The question is a practical one, and admits, according to the Lancet, of some fairly definite rules and principles. In general, children respond more readily to change than older persons. They commonly do well at the seaside; they often benefit signally by a sea-voyage, and do not suffer severely from the discomforts attending one. They suffer more than grown people from the depressing influences of city life; and, in a large proportion of cases, they are not specially benefited by the climate of high altitudes. The explanation of the love of children for the sea is that they are benefited by it, because they are commonly in a condition to bear stimulation, not having used-up nervous systems. They are attracted by the sea and its products, and by the amusements natural to the seaside; and some of their most common ailments are among the affections most amenable to sea influences. The advantages of mountain air to them are not so conspicuous, but much has yet to be learned on this subject before it can be discussed with full intelligence. Elderly people in general do well with equability and moderate warmth, bear cold badly, and are most benefited by abundant sunshine. High altitudes are rarely suitable to them, and often injurious; and they do best in level places, where there is abundant shelter. They may or may not benefit by the seaside or a sea-voyage, but these measures can not be recommended with the same confidence as to children. In nothing is the superior recuperative power of youth over age more apparent than in the greater readiness and certainty of its response to change of climate. We can confidently recommend to the young measures which we suggest dubiously to the old. In fact, change is rarely at fault in the earlier years of life, whereas it is often a doubtful and sometimes a hazardous experiment for the aged. In the case of the old, we need to have solid reasons and tolerably definite prospects before we induce them to give up the comforts and safety of home for the uncertainties of travel.

The United States Life-saving Service.—Systematic methods for the preservation of life from shipwreck were not adopted till very late in history. According to Mr. Horace L. Piper, of our Life-saving Service, the eighteenth century was "well in its twilight" before any organized effort, and that private, was made for this purpose. The first life-boat was not invented till after our independence was achieved, and George Washington had been two years President when the first serious steps in that direction were taken in England. The United States was abreast of other countries in this work. The Humane Society, organized in Massachusetts in 1786, devoted itself to it in 1789. The Life-saving Service of the United States was begun in 1848, was made more effective in 1871, and was organized into a separate bureau in 1878. For its purposes, the coasts of the Atlantic, the Gulf of Mexico, the Great Lakes, and the Pacific (excepting Alaska), comprising more than ten thousand miles, are

divided into twelve life-saving districts, designated by number, beginning with Maine on the Atlantic and ending with Washington on the Pacific. Each district is in charge of a superintendent chosen for his knowledge of the subject, business capacity, and executive ability. The districts are subdivided into stations, known by the names of their localities, and situated with regard to the special dangers of the coast. They are of two kinds: complete life-saving stations, and houses of refuge. In all there are about two hundred and forty stations of both kinds, but some of them are not yet fully completed and manned. A majority of them are on the Atlantic coast: ten on the shores of Maine and New Hampshire; six in Massachusetts, where the Humane Society provides whatever other service is needed; thirty-nine on Long Island; forty in New Jersey; seventeen between Cape Henlopen and Cape Charles; twenty-three between Cape Henry and Cape Hatteras; one station and ten houses of refuge in Florida; eight on the Gulf of Mexico; forty-nine on the Lakes; and twelve on the Pacific coast. Every station is in charge of an officer who is really the captain of the crew, but whose technical designation of keeper is a survival from the time when only one person was constantly employed and depended on volunteers for help. The crews are technically known as surfmen, and are selected by the keeper from the best men in the neighborhood. The crews are under the control of the keepers, and above these are the district superintendent, who visits the stations quarterly; the assistant inspector, who makes monthly rounds; and the general inspector, who reports periodically to headquarters in Washington. The statements of the operations of the service show that it has been very effective in saving life and property. The entire loss of lives on all the coasts of the United States under the present system since 1871 has been only thirty-eight in excess of the loss on the Long Island and New Jersey coasts alone during the preceding twenty years. This efficiency is largely due to the fact that politics has not yet intruded into the service, while the principle of choosing and keeping the best men for their work has been steadfastly adhered to.

Organic Variation a Chemical Problem.—The laws of chemism are applied by Prof. A. E. Dolbear to explain the phenomena of protoplasmic growth and change. Since the discovery of the mechanical equivalent of heat there has been no alternative but to suppose those phenomena to be due to motion. Having shown that such motions of matter as constitute sound, heat, magnetism, and the rest, all produce fields external to themselves, and that within such fields other bodies are brought into similar states of position or of motion or both, the author would apply the same principle to protoplasm and cell structure. "Imagine a cell with any degree of complexity, surrounded by material such as it is itself composed of, and what should one look for to take place if not that the same kind of a structure should be reproduced? When this happens, we say growth has taken place, and it is attributed to life. As the new cell is similar to the old one that furnished the specific conditions for its development, we say it has inherited its form and functions. The bearings of this upon the fundamental problems of biology are apparent. If the foregoing be true, heredity is explained as much as inductive magnetism is, and is no more mysterious. . . . Suppose that in such a complex molecule as protoplasm a single atom of a different substance should accidentally become imbedded, either as a constituent or not, it would bring its field along with it necessarily, and the resultant field of the whole would be modified. It could not be what it would be in the absence of this new constituent, and consequently the reaction upon other matter in its neighborhood would be different, and the next organic molecule formed would need to be a little differently organized. Mechanical conditions would necessitate it. Again, if energy, radiant or conducted, should act for a short time upon one part of a molecule, it might easily bring about an exchange of positions among some of the less stable constituents without other disturbance, and this too would result in a change of the configuration of the field and the direction of growth. Every change in the collocation and motions among molecules exhibits itself in changed properties. Such conditions might properly be spoken of as changes in the environment, but it is mo-

lecular environment, and the difference between this idea and that heretofore common is, that the molecule produces an environment of its own—the space beyond its own geometric boundary, in which it is competent to act upon other bodies and compel other bodies to conform in a greater or less degree to it. More than that, a new constituent in a nearly saturated molecule could not have as firm a grip upon the structure as the older constituents could have, although it might so modify things while present as to organize other molecules in like manner, but slight changes in the neighborhood might slough off the new acquisition in a subsequent generation, so there might be a return to the form and qualities of the ancestry—that is, reversion to a former type would also be a mechanical consequence. Thus growth, heredity, variation, and reversion may be considered as the consequence of atoms vibrating in harmonic orders, each producing its own field in the universal ether, and each group of atoms constituting a molecule, large or small, having a field which is the resultant of all the fields of its constituents. All of them are molecular properties as much as any one of them can be, and growth has been believed for a long time to be a property of inorganic molecules. The cause of variation is therefore molecular as truly as isomerism is a different collocation of atoms. It is a chemical problem."

Snake-myths.—A great deal of nonsense has been published, and a great deal more is believed, about snakes. Some most thrilling stories turn upon a power which serpents are credited with of fascinating their victims. This appears to be a superstition. According to Mr. Vincent Richards, mice, birds, dogs, guinea-pigs, and other small animals, introduced into a rattlesnake's cage, show little fear, even at first, and afterward none whatever. Smaller birds, after fluttering about till they are tired, end by becoming amusingly familiar with the snakes. Mr. Richards put two rats into a cage containing forty cobras. At the outset the rats' appetites were considerably affected, and they were evidently alarmed. In a short time, however, they recovered their spirits, and caused considerable commotion among the cobras by running all over their heads and bodies. The snakes resented this familiarity by darting at each other and at imaginary foes. The rats lived and partook of food in the cage for ten or twelve days, when, one after another, they were found dead—"victims, no doubt, of misplaced confidence." It is still a matter of debate whether snakes are proof against their own poison. The remedies advised for snake-bite are of doubtful validity. Because a man recovers after being bitten by a snake, and dosed with opium, mercury, ammonia, or what not, we must not jump to the conclusion that the treatment has effected a cure. A snake may bite without poisoning. Biting, though in appearance simple enough, consists really of a series of complex movements, following rapidly one upon another in ordered sequence, should any of which be inadequately performed, the victim may not be properly poisoned. Ammonia, alcohol, and making the patient move about, are worse than useless; for they increase the activity of the circulation, and thereby promote the absorption of the poison. Even permanganate of potash is of no effect unless it is administered within four minutes. Researches into the nature of the poison have shown that it resides in some proteid, and that there are three toxic elements—globulin, serum albumen, and acid albumen—but wherein the quality consists that gives to these substances, usually so harmless, their poisonous power, is as much in the dark as ever.

The Gems of the Ancients.—The gems of the ancients, according to Prof. J. H. Middleton's book on the Engraved Gems of Classical Times, consisted chiefly of the varieties of quartz—including colorless rock-crystal, amethyst, sard, carnelian, chalcedony, chrysoprase, plasma, jasper, onyx, and sardonyx. Among the non-silicious stones were chrysoberyl, topaz, emerald, garnets, peridote, turquoise, opal, and lapis lazuli. The translucent stones are preferred, for artistic purposes, to the transparent ones. They admit the light, but not the forms of objects, and better reveal the charms of fine and noble workmanship. Many "gems" have been wrought or reproduced in paste and glass. Paste was a hard glass colored by various metallic oxides, such as those of manganese, iron,

copper, and cobalt. Sometimes a piece of paste was treated by the gem-engraver just as if it were a natural stone, and sculptured by the aid of the same tools; but more generally the glass was melted and pressed into a mold. Such a mold had been taken from an engraved gem by a pellet of clay which was afterward hardened by fire. Paste gems are often beautiful in color and design, though the material lacks something of the optical properties which distinguish many of the true natural stones. The tools and processes employed in ancient times in engraving gems were virtually the same as those in use to day—drills, wire saws, and files, re-enforced with emery, and gravers of diamond, sapphire, or rock-crystal.

Courtship in Torres Strait.—The people living on the islands of Torres Strait are divided by Prof. Arthur C. Haddon into the eastern and western tribes, and customs differ considerably among them. While the usual course in marriage is followed by the eastern tribe, in the western tribe the girls propose—or did, till "civilization" overtook them—marriage to the men. "It might be some time before a man had an offer; but should he be a fine dancer, with goodly calves, and dance with sprightliness and energy at the festive dances, he would not lack admirers. Should there still be a reticence on the part of his female acquaintances, the young man might win the heart of a girl by robbing a man of his head. Our adventurous youth could join in some foray; it mattered not to him what was the equity of the quarrel, or whether there was any enmity at all between his people and the attacked. So long as he killed some one—man, woman, or child—and brought the head back, it was not of much consequence to him whose head it was. . . . The girl's heart being won by prowess, dancing skill, or fine appearance, she would plait a strong armlet, *tiapururu*; this she intrusted to a mutual friend, preferably the chosen one's sister. On the first suitable opportunity the sister said to her brother, 'Brother, I have some good news for you. A woman likes you.' On hearing her name, and after some conversation, if he was willing to go on with the affair, he told his sister to ask the girl to keep some appointment with him in the bush. When the message was delivered, the enamored damsel informed her parent that she was going into the woods to get some wood or food, or made some such excuse. In due course the couple met, sat down and talked, the proposal being made with perfect decorum. The following conversation is given in the actual words used by my informant, Maino, the chief of Tud. Opening the conversation, the man said, 'You like me proper?' 'Yes,' she replied, 'I like you proper with my heart inside. Eye along my heart see you—you my man.' Unwilling to give himself away rashly, he asked, 'How you like me?' 'I like your fine legs, you got fine body—your skin good—I like you altogether,' replied the girl. After matters had proceeded satisfactorily, the girl, anxious to clinch the matter, asked when they were to be married. The man said, 'To-morrow, if you like.' They both went home and told their respective relatives. Then the girl's people fought the man's folk, 'for girl more big' (i. e., of more consequence) 'than boy'; but the fighting was not of a serious character, it being part of the programme of a marriage. 'Swapping' sisters in matrimony was a convenient way of saving expense in the way of wedding gifts, for one girl operated as a set-off to the other."

Value of Photography.—The name of impressionists has been given to a school of painters who, abandoning all consideration of the arrangements and mechanism of previous workers, have consulted only their impressions of natural scenes, and have painted to those impressions. "With one point of sight and one subject of supreme interest they have aimed to seize above all the action and first impression of that subject." The naturalistic school trust rather to a study of Nature, and make its truthful representation and perfect expression the criterion of their art. Mr. George Davison sees no reason why photography should not be used to express our impressions of natural scenes as well as any other black-and-white method. Worked under the same conditions as the eye, or under conditions as nearly approximate as possible, nothing, he says, gives so truthful a record in drawing as photography, and nothing, when the proper means are used and the requisite knowledge is possessed by the

photographer, gives so delicately correct a relation of tones. It is to the proper use of the proper means at their disposal that photographers need stimulating. The most important of these means are such as are directed to securing the proper light effect and relations of light values, and those which give the focusing and relative interests of the subject. Some of the simplest facts of light are overlooked by photographers, who have been governed by untrue and misleading conventions and dogmas concerning gradation and brilliancy. Instead of deep black prints usually in favor among them, it is of first-rate importance in landscape pictures to keep the shadows light. To repeat the impression of outdoor light the whole picture must be luminous, and not heavy and dark, as is the effect of the ordinary style. Further, the shadows when the sun shines are lighter than when he is obscured. The printing medium employed is an important consideration. Mr. Davison finds excellent qualities in the newest extra rough-surfaced papers. Photography is good under suitable conditions of light for representing transient action and effects. Photography has preeminently more of painting qualities than any other monochrome process. It is not specially limited to nor compelled to emphasize facts of form. It gives form by means of tone against tone—the best means of rendering it—and its truth of form is unlimited. It is equal to any other black-and-white process. In nothing more than closed forms is the delicacy of its tonal discriminations shown. The quality of naturalness will tell in the long run. Men will weary of emphasis, and graphic artists will leave past history, archæology, and fiction to literature or scientific drawing.

A Voodoo Initiation.—A paper was communicated to the International Folk-lore Congress in London by Miss Owen on Voodoo Magic, to the mysteries of which she alone among white women had been initiated. The ceremony of initiation began with a walk at midnight, barefooted and bareheaded, to a fallow field. The author had to walk backward to the field, and when there, to pull up, with her hand behind her, a weed by the roots. She was then bidden to run home and throw the weed under her bed, to be left there till sunrise. Next, the weed had to be stripped of its leaves and made into a little packet, to be worn under the right arm for nine days. At the end of this time the leaves of the packet had to be scattered to the four winds, a few being thrown at a time over the right shoulder as the novice turned round and round, so that they might fall north, south, east, and west. When this was done the novice was ready for instruction. She learned that the preeminently lucky number which, when woven into incantations, was irresistible, was four times four times four; while ten was the unlucky number. After this a knowledge of the value of certain vegetable remedies and poisons had to be acquired. Charms were divided into four degrees. The first were good charms, the hardest to work, because good is always more difficult to practice than evil; the second were bad charms and fetiches made in the name of the devil; the third had special reference to bodily ailments; and the fourth related to what were called "commanded things," such as earth and pieces of stick. After each lesson both pupil and teacher had to get drunk, either by drinking whisky or by swallowing tobacco-smoke. To be thoroughly equipped the novitiate must possess a conjuring-stone—a stone black, kidney-shaped, and very rare. These stones were supposed to operate most rapidly when the moon was full or just beginning to wane. At other times, if the stones were not efficacious enough, their potency could be stimulated by a libation of whisky.

Cremation in Japan.—We are indebted to a correspondent of the London Spectator for the following interesting account of this method of disposing of the dead in Meguro, Tôkeigô. It appears that cremation is the general custom among the "Monto sect of the Buddhists," a highly enlightened branch of Japanese Buddhism, which holds to the immortality of the soul as one of its leading tenets. "The building is of plaster, with an earthen floor, with stone supports for bodies. The chimneys are wide, and are carried to a considerable height, and there is no escape of disagreeable effluvium over the neighborhood. The bodies in the ordinary wooden chests which are used for burial are placed

upon piles of fagots at 8 P. M., and are *totally* consumed by 6 A. M. The relations are admitted early in the morning, and the ashes are collected and placed in urns. The scale of charges is 3*s.* 6*d.*, 7*s.* 6*d.*, 15*s.*, and 20*s.*, the process in each case being the same, the only difference being that the highest charge insures a solitary chamber, while for the lowest the corpse may be consumed in company with five others, each, of course, occupying a separate stone platform."

Chinese Cookery.—It appears, from the Pall Mall Budget, that the great number of strange dishes spoken of in books of travel are seen only at official banquets, and do not constitute the meals even of the wealthy Chinese. These public dinners are usually given in restaurants, which are built two or three stories high, the kitchen and public rooms being on the first floor, the private rooms above. A correspondent of the Journal des Débats gives the following as the bill of fare at a banquet given by a French official of the Chinese Government to Chen Pao-Chen, the Viceroy of the Two Kiangs: "Four large 'classical' or stock dishes—swallows'-nest soup with pigeons' eggs, sharks' fins with crabs, trepang (*bêche de mer*) with wild duck, duck with cabbage. Dishes served in cups placed before each guest—swallows' nests, sharks' fins, wild cherries, vegetables, mushrooms with ducks' feet, quails, pigeons in slices, dish of sundries. Four medium-sized dishes—ham and honey, pea-soup, vegetables, trepang. Four large dessert dishes—pea-cheese with bamboo roots, bamboo roots, chicken, shell-fish; four dishes of dried fruits as ornaments, four kinds of dry fruits, four kinds of fruits in sirup, four kinds of fresh fruit; four dishes of *hors d'œuvre* (two varieties in each dish)—ham and chicken, fish and gizzard, tripe and vermicelli, duck and pork chops. Dishes set before each guest—almonds and watermelon pips, pears and oranges. Sweet and salt dishes served in cups set before each guest—two kinds of salted cakes, ham-broth, a broth composed of pork, chicken, and crab boiled down, two sweet cakes, a cup of lotus fruit, a cup of almond milk. Roast and boiled meats—sucking pig, roast duck, boiled chicken, boiled pork. *Entremets*—a dish of cakes with broth, slices of pheasants. Last service—mutton broth, almond jelly, white cabbage, pork and broth, bowls of rice, cups of green tea." Notwithstanding this elaborate "bill of fare," the Chinese are generally an abstemious people. A coolie will subsist upon eight shillings a month, and live comfortably upon twice that sum. Boiled rice is the staple article of food. In the north of China wheat and canary seed, boiled and made into small rolls, are much used. Small cakes made of boiled wheat, together with a little fish or some vegetables, constitute an excellent dinner for a Chinaman. Some light refreshment is frequently taken between meals by the well-to-do Chinaman—"the kuo tsâ leading up to the morning, the kuo tsong to the midday, and the tien chen to the evening meal, while the chian ya and the kuo yia are partaken of during the night by those who can not get to sleep."

A Defense of Opium-smoking.—That there is no cause without its advocate is evident from the fact that Consul Gardner, in a trade report for the past year, plausibly defends the practice of opium-smoking. We gather the following from the Pall Mall Budget: About 12,000,000 pounds of opium are yearly consumed in China. The smokers are of three classes—occasional smokers, habitual moderate smokers, and excessive habitual smokers. When a Chinaman is said to smoke opium, the recognized meaning is that he belongs to the third class, just as with us when we say that a man "drinks," excessive drinking is understood. In smoking, only part of the drug is consumed; the ash when reprepared yields fifty per cent of opium. This accounts for the fact that the saloon-keepers sell opium at what appears to be cost price; the ash yields the profit and pays for light, house-rent, and attendance. It is estimated that the immoderate smoker consumes not over four pounds a year, and the average annual consumption of all classes is half a pound. If, as this implies, half the adult population smoke, and opium-smoking is the evil it is represented to be, why are there not visible inherited ill effects? Consul Gardner, in reply, says: "The length of the intestines in man shows that a due admixture of animal and vegetable food is the diet best suited

to him. In China the population lives almost entirely on vegetables. Opium-smoking slows the processes of digestion, and, in fact, has the same effect as long intestines, and consequently is highly beneficial." Again, the Chinese live in low, undrained grounds, and are consequently liable to attacks of fever and ague. Under similar circumstances the lowlanders of Lincolnshire took to laudanum; the Chinese take opium in another form. Residents in China are struck with the comparative freedom of the people from pulmonary diseases. "That this immunity is not due to climatic influences is clearly proved by the fact that Europeans and Americans are not more free from the scourge in China than they are in their own countries." Morphia is an anæsthetic, and rarefied as smoke probably an antiseptic. "In this form it would tend to arrest the suppuration of the lungs that takes place in consumption."

Oscillations of Alpine Glaciers.—About thirty years ago, according to Herr von E. Richter, the glaciers of the Alps began a precipitate retreat. In 1870 the traveler often found a stone-strewn plain or an undulating slope of polished rock where ten years before he had scrambled over crevassed ice. About five years later, a slight, transitory forward movement was perceptible, while now the indications of an advance are becoming more marked. Similar changes, at earlier dates, are on record, and their history has been studied by Prof. Forel, Herr von Richter, and others. The historical period of the oscillations of the glaciers extends back about three centuries, while prior to this the notices are too sparse and vague to be of any real use. In this period eight marked epochs of glacier growth are on record. The first began in 1592, and the last, excluding the slight one of 1875, in 1833. Each was followed by a period of diminution. The intervals between the epochs vary from twenty to forty-seven years. The observations are not numerous enough to give trustworthy indication of a law, but are supposed to hint at one. The changes are connected with climatic variations, but effects are produced more quickly than is generally supposed. In the present century the curves representing the oscillations of the glacier and those of the annual temperature nearly correspond. Some traditions assert that in the middle ages the glaciers had almost melted away from many parts of the Alps, and passes were then crossed by women and children which are now left to experienced mountaineers. Their evidence relates to the cultivation of vines, cereals, etc., in localities where they are no longer grown, and to the former use of passes which are now practically closed. To the former evidence, as Herr Richter shows, little weight can be given. Man and Nature are in constant conflict in the Alps, and the position of the frontier line between their territories is determined by the convenience of the former. If a particular form of cultivation ceases to be remunerative all the advanced posts are abandoned. Herr Richter, likewise, does not give much force to evidence based on the disuse of passes. This is more than likely to have been brought about by the discovery of better ways or the making of new roads. In short, says the Saturday Review, under this author's treatment, "the traditions, not the glaciers, become unsubstantial, and the warm epoch in the mediæval history of the Alps goes the way of many other legends."

Origin of the Colors of Flowers.—Any one, says Mr. E. Williams Hervey, in Garden and Forest, can solve the problem as to the primitive color of flowers by a study of the native wild plants growing by the roadside or in the fields and woods. Two methods, he says, are employed by Nature in the development of colors, one of which he calls the imperfect or foliar development, and the other the normal floral process. In the former, the colors are apparently evolved directly from the green chlorophyl, as the reds, purples, and yellows of autumn leaves; for from some green-colored flowers a rather limited number of dull reds, purples, and yellows are produced. The reds and reddish purples are, however, rare, and appear mostly on the scales of involucres, where they are common, on the spathes of several of the *Araceæ*, in *Salicornia* of the salt marshes, which turns red in the fall, and in the castor-oil plant of gardens, which turns a reddish purple in all its parts. The author does not find a satisfactory example of yellow evolved

directly from green among our native plants, and doubts if any pure yellow ever immediately succeeds green. But there are some greenish-yellow flowers. For illustration of the normal floral method of development by which he believes all the bright, attractive hues of the floral world are produced, the author takes up the *Spiranthes gracilis*, or ladies-tresses, an orchid which grows in all our fields, having small white flowers spirally disposed at the summit of the scape. The lip is green, fringed around the edges with white, and the other petals are wholly white. "A small section of the petals, placed under the magnifying glass, appears colorless and transparent, while the delicate network of the tissue glistens like crystal; yet this colorless tissue, in a mass, reflects white. In the same manner a single leaf-like bract of *Monotropa uniflora*, severed from the stem, appears colorless; but two or more placed together, making a greater thickness, reflect a decided white color." Attention is called to the fact that in *Spiranthes* the white color directly succeeds the dark rich green of the lip. The author then endeavors to demonstrate that the universal law of progression in color, as regards the floral structure, is first from green to white; "or, differently stated, Nature, before she begins to paint the more rich and delicate tissue of the petals, by some secret chemical process completely eliminates the chlorophyl and prepares a perfectly pure and white canvas upon which to essay higher flights of fancy." Twenty-eight wild and garden flowers are cited as illustrating this principle in the development of their colors, and numerous inconspicuous or weed-like plants in the coloring of their sepals; while the hues of flowers of other colors are thus produced by transition through white, "without a single exception every flower that came to hand of a white color was developed directly from green, without any intervening color."

Canaries.—A correspondent of the London Spectator writes chattily of his pet canaries, and seems to show that they are very human in their reason and unreason. During some intensely hot weather, when the hen was sitting, she drooped, and it seemed as if she might not be able to hatch her eggs. The cock, however, showed himself an excellent nurse. After bathing in fresh cold water, he went every morning to the edge of the nest and allowed the hen to refresh herself by burying her head in his breast. A green and yellow canary hung side by side, and were treated exactly alike. One day three dandelion blossoms were given to the green bird and two to the yellow one. The latter showed his anger at the proceeding by "flying about his cage, singing in a shrill voice." But when one of the three flowers was taken away, both birds seemed quietly to enjoy their feast.

Utilizing the Less-known Metals.—In closing his presidential address before the Chemical Section of the British Association, Prof. Roberts-Austen spoke of the great importance of extending the use of the less-known metals. He supposed that in the immediate future there would be a rapid increase in the number of metallurgical processes that depend on reactions which are set up by submitting chemical systems to electrical stress. Attention is at present concentrated on the production of aluminum. Sodium, also, is of growing importance, both for cheapening the production of aluminum, and as a powerful weapon of research. The manufacture of magnesium, which was a curiosity in 1849, has become an important industry. We may confidently expect to see barium and calcium produced on a large scale as soon as their utility has been demonstrated by research. Minerals containing molybdenum are not rare; and the metal could probably be produced as cheaply as tin if a use were to be found for it. The quantities of vanadium and thallium which are available are also considerable; but we as yet know little of the action when alloyed of those metals which are in daily use. The field for investigation is vast, for it must be remembered that valuable qualities may be conferred on a mass of metal by a very small quantity of another element. The useful qualities imparted to platinum by iridium are well known. A small quantity of tellurium obliterates the crystalline structure of bismuth; but we have lost an ancient art, which enabled brittle antimony to be cast into useful vessels. Two tenths per cent

of chromium increases the strength of gold enormously, while the same amount of bismuth reduces the tenacity to a very low point. Chromium, cobalt, tungsten, titanium, cadmium, zirconium, and lithium are already well known in the arts, and the valuable properties which metallic chromium and tungsten confer upon steel are beginning to be generally recognized.

NOTES.

THE Electrical Engineer begins the new year with the publication of the first of a series of articles on the electrical and magnetic discoveries of Prof. Joseph Henry, by his daughter, Miss Mary A. Henry, of Washington, with notes by Mr. Franklin Leonard Pope. Additional interest is given to these articles by the fact that the author will endeavor in them to substantiate the claim that Prof. Henry was the original discoverer of magneto-electricity.

A GERMAN physician, Dr. Krug, claims that he has discovered how to make an eatable and nutritious cake with wood. His method consists in transforming the cellulose into grape sugar, a substance assimilable by the animal organism. The biscuit is made by adding to this about forty per cent of meal of wheat, oats, or rye. Phosphates and all the bone elements may also be introduced. This bread of wood-glucose is intended to be fed to cattle, for which it will take the place of oil-cakes and other feeds composed of industrial wastes.

THE Council of the School of Mines in England has determined that the room at South Kensington containing the library of research presented by Prof. Huxley to the institution, and in which he taught for nearly twenty years, shall be entirely set apart as the Huxley Laboratory for Biological Research. An endowment of one thousand pounds bequeathed for the establishment of a prize or scholarship in biology, has become available, together with the scientific books and instruments, and its proceeds will be appropriated annually in aid of a student in this laboratory, which now has provision for two students.

MR. ALBERT KOEBELE, of our Bureau of Entomology, who is studying the enemies of insect pests in the Australasian colonies, was recently introduced by Sir James Hector to the Wellington Philosophical Society, New Zealand, as a naturalist whose work in securing the Vedalia lady-bird to destroy the Iceria pest of the California orchards is "one of the grandest things in the interest of fruit and tree growers that have been effected in modern times."

A CORRESPONDENT of the Geneva (Switzerland) Tribune relates that his family were disturbed one evening by a mysterious ringing of the electric bells all over the house. Investigating the cause, the writer found that a large spider had established itself at a point where the bell and the electric light wires ran close to one another, with one leg on either wire, thus establishing a connection.

A SPECIMEN of prehistoric hatchets of peculiar form was exhibited by M. Villanova, of Piera, at the meeting of the French Association. About two hundred of them had been found at Elcho. They were simple emblems or images of a hatchet, made of a thin blade of metal, ornamented on both sides from one end to the other, and without edges. At the top is a kind of cup suggesting a socket that does not exist, and representing, probably, the jet of the casting.

JAVA is said to be the region of the globe where it thunders oftenest, having thunderstorms on ninety-seven days in the year. After it are Sumatra, with eighty-six days; Hindustan, with fifty-six; Borneo, with fifty-four; the Gold Coast, with fifty-two; and Rio de Janeiro, with fifty-one. In Europe, Italy occupies the first place, with thirty-eight days of thunder, while France and southern Russia have sixteen days, Great Britain and Switzerland seven days, and Norway only four days. Thunder is rare at Cairo, being heard on only three days in the year; and is extremely rare in northern Turkistan and the polar regions. The northern limit of the region of thunderstorms passes by Cape Ogle, Iceland, Nova Zembla, and the coast of the Siberian Sea.

A PRIZE of four hundred kronen is offered by the Royal Danish Academy of Sciences at Copenhagen for investigations on the exact nature and proportions of the more important carbohydrates present, at different stages of maturity, in the cereals in most general use.

THE use of aluminum is recommended by Mr. G. L. Addenbrooke, instead of brass, for the framing of photographic lenses and the metal parts of cameras; for the revolving tripod heads fixed in the base-boards of cameras; and for developing dishes, for which he regards it as very suitable, for the action of most of the chemicals used in photography is very slight upon it, and, when there is any, the compounds formed would not be harmful.

IN the course of an account of various marriage customs, Dr. A. H. Post refers to a strange sort of symbolical marriage with plants, trees, animals, or inanimate objects, which is supposed to have originated in India. If any one proposes to enter upon a union that is not in accordance with traditional ideas, it is believed that the ill luck which is otherwise sure to follow may be

averted by a marriage of this kind, when the evil consequences will pass over to the object chosen. In some regions a girl must not marry before her elder sisters, but in parts of southern India the difficulty is overcome by the eldest daughter marrying the branch of a tree. Then the wedding of the younger daughter may be safely celebrated.

FACTS well known to boys who are familiar with the woods are reported by Mr. C. Fitzgerald in The Zoölogist. During many winters passed in the backwoods of North America, he has seen squirrels frisking among the trees in the coldest weather. On bright, sunny days especially, they delight in chasing one another from tree to tree among the evergreens, and cover the snow with their tracks. The chipmunks lay up in the autumn a store of provisions of grain, nuts, etc., for winter, and may be seen sunning themselves on bright days. Mr. Fitzgerald has on several occasions come across their hoards, and once saw two large bucketfuls of shelled buckwheat taken from the hollow of an old birch tree.

FRUIT-TREES are planted along the roadsides of several countries of Europe, but it has not been usual to attach great importance to the value of their products. Recent estimates made in Germany show that this is considerable. The roadside trees of Hanover gave a gross return in 1890 of 270,000 francs, of which 187,000 francs were derived from the fruits. The roadside fruits of the Hildersheim region returned 64,000 francs, and those of Göttingen 41,000 francs; and the district of Reutlingen, according to the *Gartenflora*, derived 333,000 francs from the sale of these fruits. The trees of the Monheim district, first planted in 1858, yielded 9,500 francs in 1868, 22,000 francs in 1878, and about 36,000 francs in 1888.

OLD newspapers are said to make valuable anti-moth wrappers for furs and winter clothing, the ink upon them being nearly as repulsive to all kinds of vermin as camphor or coal-tar paper. They are likewise good to lay on carpets for a like purpose. Being impermeable to air, they also form excellent envelopes for vessels containing ice and fresh liquors.

GARDEN AND FOREST tells the story of two famous trees which were saved from destruction, each by the sagacity and liberality of a man who appreciated their value. One is the giant Manzanita (*Arctostaphylos manzanita*), of St. Helena, Cal., which a woodchopper in the employ of the Napa Valley Wood Company had begun to cut down when Dr. C. Hitchcock, passing by, paid two dollars to have it saved. The other is the fine red oak of Dedham, Mass., which Thomas Motley, father of the historian, who owned the adjoining place, paid its owner to have spared. Both of these trees are now owned by men who will preserve them. The names of the men to whom their continued life is due deserve to be remembered.

OBITUARY NOTES.

OUR French papers bring news, with no particulars, of the death, January 12th, of M. A. de Quatrefages, the eminent anthropologist, at the age of eighty-two years.

M. JEAN SERVAIS STAS, the distinguished Belgian chemist, died at Saint-Gilles, near Brussels, December 13th, after a short illness. He was born at Louvain in 1813, studied in Paris under Dumas, and, returning to Belgium, became a professor in the Military School. He was afterward Commissioner of Moneys, a member of the Commission of the Observatory, and, after the death of Houzeau, of the Committee of Direction, Belgian representative in the International Committee of Weights and Measures, member of many learned societies at home and abroad, and bearer of many honors. His chemical researches were numerous, and have been much quoted from.

DR. H. K. H. HOFFMANN, Professor of Botany at Giessen, and Director of the Botanic Institute there, died October 27th, in the seventy-third year of his age.

EDOUARD MAILLY, formerly aid at the Royal Observatory of Belgium, died October 8th, in his eighty-second year. He entered the Observatory as a computer in 1832, and occupied himself there with the reductions of the meridional observations. He published in the Annuaire of the Observatory, and in the Academical Collections, a number of works in the history of science which were highly prized. Among them were essays on the Scientific Institutions of Great Britain and Ireland, Spain, Italy, and the United States, a sketch of Astronomy in the Southern Hemisphere and in India, papers on the history of the Belgian Academy, biographical notices of Adolphe and Ernest Quetelet, Van Ries, and Argelander, and a book of reminiscences.

THE RIGHT REV. HARVEY GOODWIN, Bishop of Carlisle, who died in York, England, November 25th, took a prominent part in the discussion of questions involving the interrelations of science and religion. Being an eminent mathematician, as well as a distinguished theologian, he enforced his arguments with mathematical methods and principles, which added greatly to their effect. He was clear, judicious, and temperate in argument, and rarely missed the essential point. The papers by him which have been published in the Monthly attest his ability in this particular.

PROF. JOSEPH LOVERING, Hollis Professor Emeritus of Harvard College, died January 18th of heart-failure following grip, in the seventy-ninth year of his age. A full sketch of his life and scientific activity till his retirement from work in 1888 was published in the Monthly for September, 1889.